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Factors in the Mass Mortality of a Herd of Sika Deer, *Cervus nippon*[1,2]

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ABSTRACT

A six year population study on sika deer, *Cervus nippon*, introduced in 1916 on James Island in Chesapeake Bay, Maryland, provided unique results because of the unusual completeness of the data due to an islandic situation. A density of one deer per acre was reached in 1955. In 1958, 60 percent of the population, mainly young and females, died during January and February. Gross and microscopic studies were made on 18 deer, shot and autopsied in 1955, 1957–60, plus one recently dead at the time of the die-off.

Adrenal weight increased, especially in the young, from 1955 to 1958 and then dropped 50 percent following the die-off. Inhibition of growth observed before and during the die-off vanished afterwards. Changes in the adrenal *zona glomerulosa* and medulla suggested overstimulation and a severe imbalance of fluid-electrolyte metabolism as the cause of the die-off. These changes may have been secondary to prolonged hyper-stimulation of the cortex as a result of excessive population density and its resultant social pressures. An inclusion hepatitis and glomerulonephritis are described which involved all deer, especially after 1958, but not in 1955. These diseases were ruled out as causal factors in the die-off, as were malnutrition and poisoning. The deer were apparently in good nutritive status throughout.

It was concluded that physiological derangements resulting from high population density produced the observed effects.

Introduction

For many years the physical deterioration and increased mortality of deer herds which often occur in winter have been attributed, with few exceptions, to malnutrition or starvation (Latham, 1950; Leopold *et al.*, 1951; Longhurst *et al.*, 1952; Dasmann, 1956; Swank, 1956). However, competent observers occasionally have suggested that malnutrition may not be the common critical factor (Cheatum, 1952) but that other and more subtle agents may be more important than food. In fact, malnutrition often is an *ex post facto* diagnosis, with critical studies lacking (Longhurst *et al.*, 1952). The deer are dead and appear to be in poor condition—therefore they must have starved. Actually, the diagnosis of malnutrition usually is based on macroscopic changes in the carcasses, changes that are known to be non-specific and that can be induced by a variety of factors which impose unusual demands on physiological adaptive processes. Evidence will be presented here to show that at least in sika deer, *Cervus nippon*, population density, not food, can be the major factor that limits both physical condition and numbers.

Material and Methods

This study concerns the herd of sika deer on James Island, Maryland, a tract of 280 acres located off the Eastern Shore of Chesa-

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Fig. 1.—Part of a herd of sika deer, *Cervus nippon*, on James Island, Maryland, in May, 1958, to illustrate the well nourished and healthy appearance that characterized the animals throughout the period of study. Photograph by Ted Kell, courtesy of the *New York Herald Tribune*.

peake Bay. Fig. 1 shows the species under typical conditions on James Island. The history of this herd has been reviewed recently (Flyger and Warren, 1958; Flyger, 1960). The present phase of observations on the herd began in 1955 when a census indicated a population of 280–300 deer, a density of one per acre, at which time a die-off seemed inevitable.

Accordingly, deer were shot for study in April 1955, April 1957, March 1958, February 1959, and March 1960. Autopsies usually were begun within a half-hour after death, and representative blocks of tissue were fixed in 10 percent neutral formalin. All carcasses were weighed before and after dressing during 1955, thereafter weights were taken only before dressing. Also in 1955, adrenals, thyroids, thymuses, spleens, and ovaries of all animals were weighed. Thereafter only adrenal weights were recorded. Age was determined by the method of Severinghaus (1949) assuming that the wear and replacement of sika teeth were comparable to those in white-tailed deer. The teeth of the two species appear to be similar enough to warrant this treatment.

Histological sections of 5 micra or less in thickness were cut from the adrenals, kidneys, liver, thyroids, thymus, spleen, gonads and adnexa, heart, aorta, lungs, and other tissues that appeared to be of importance to the study. Sections were stained by Lillie's allochrome as well as haematoxylin and eosin (Lillie, 1954). In addition, frozen sections of the livers from the 1960 sample were stained with Sudan IV for fat. Sections supplied by Dr. Frank Hayes, from a deer which had succumbed during the die-off in 1958, also were examined.

Additional gross weights were supplied by the Maryland Department of Research and Education.

The data in this study were not evaluated statistically, as the differences in the critical data were so great that such treatment was not warranted.

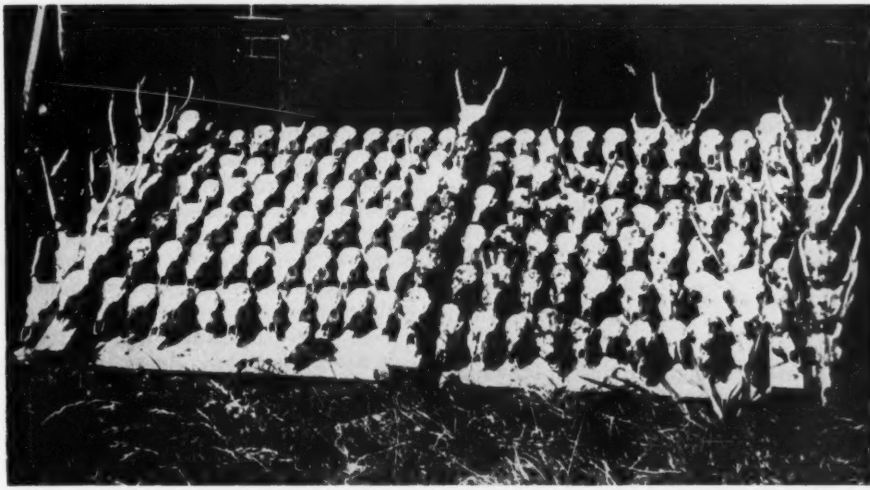

Fig. 2.—Skulls of the 147 sika deer, *Cervus nippon*, recovered on James Island, Maryland during the die-off in 1958. Reproduced from a kodachrome taken by V. F. Flyger.

Results

History and Habits of the Herd

This herd grew from an initial introduction of four or five deer in 1916 (Flyger and Warren, 1958; Flyger, 1960). The recent numerical history of the herd, in brief, is as follows: In April, 1955 the population was estimated to number between 280 and 300 deer. No change was noted in 1956 or 1957 but, from late January 1958 through March 1958, many deer died and 161 carcasses were recovered (probably none missed). Fig. 2 shows a collection of sika deer skulls taken during that period. A count of 109 surviving deer was obtained under unique circumstances following a deer drive in April 1958 (Flyger and Warren, 1958), hence the number of deer prior to the die-off was at least 270. Therefore the population had remained stationary at one deer per acre from April 1955 (or earlier) through December 1957. Counts indicated that the herd had declined further the following year to approximately 80 in 1959. Females and young were the predominant victims during the die-off (Table 1). The sex and age composition of the survivors is not known.

Table 1.—Sex and age composition of sika deer, *Cervus nippon*, carcasses found on James Island, Maryland from February through April, 1958.

Sex	Age Group					
	Calf (Less than 12 mos.)	1–2 years	2–3 years	3 years and over	Undetermined	Total
Male	—	6	8	6	—	20
Female	—	10	22	28	—	60
Unknown	50	1	8	8	14	81
Total	50	17	38	42	14	161

The diet of sika deer is more cosmopolitan than that of white-tailed deer. On the island sikas eat wax myrtle, grasses, red maple, red gum, loblolly pine twigs, needles, bark, and tree roots. Many plants have been grazed or browsed so heavily that they no longer exist or are rare on the island, and for this reason statements concerning food preferences cannot be made. Japanese honeysuckle and greenbriar, which are common on the adjacent mainland, are not seen on the island. Poison ivy leaves are found only on trees above the reach of the deer. Many of the loblolly pines on the island bear extensive scars where deer have stripped the bark from the trees. No change in the ap-

TABLE 2.—Temperature, precipitation and snowfall recorded at the Blackwater Wildlife Refuge, Dorchester County, Maryland, approximately 15 miles east by southeast of James Island, during the winters of 1956 through 1960.

	Mean Monthly Temperature				Total Precipitation				Total Snowfall			
	Jan.	Feb.	Mar.	Dec.	Jan.	Feb.	Mar.	Dec.	Jan.	Feb.	Mar.	Dec.
1956	33.2	39.3	42.9	46.4	2.2	3.7	4.1	2.4	3.0	0	0.5	0
1957	34.8	41.7	44.6	41.2	3.5	4.1	3.8	5.6	12.0	4.0	0	3.0
1958	33.6	31.2	40.7	32.6	3.6	4.5	6.0	2.1	4.0	7.0	7.0	10.0
1959	35.3	37.8	45.5	43.5	3.2	2.2	3.0	3.7	2.0	0	T	0
1960	41.0	39.6	34.9	—	2.7	3.6	1.7	—	T	5.0	15.0	—

pearance of the vegetation due to browsing could be detected from 1955 through 1960. In particular, there was no change in the degree of browsing on pine bark. Bark peeling has been a habit of the deer, at least as long as the authors have visited the island (1955). Consumption of tree bark apparently is a characteristic of the species. For example, in Denmark sika deer are considered a serious nuisance because of their habit of bark-peeling and browsing young trees (Jensen, 1959; and Flyger, 1959).

According to local residents and observations by the authors the deer are most active at night. Large herds of over 40 animals frequently swim to the mainland at night (a distance of about a mile) or wade across the water between the north and south island. Since the 1958 die-off most of the deer (probably 90 percent) spend the daylight hours on the south island. Sika deer probably are established on the mainland but some people believe that they reside only on the island and make excursions to the mainland. Because of their secretive nature and nocturnal habits observations on sika deer are difficult to make.

People on the mainland adjacent to the island (plus a lone resident on James Island) are interested in these unique deer and provide what little is known about these animals. On two occasions (January-February 1958 and March 1960) the deer did not commute when ice formed around the island or against the mainland. The die-off occurred at the time of, and following the ice conditions in 1958 (Table 2). However, following 10 days of severe cold and ice in March, 1960, two trips were made to the island for the purpose of examining the deer. On one occasion about 40 deer were seen at close range and all appeared to be in good condition. On the second trip five men walking about on the island found no dead deer. Again all deer seen appeared to be in good condition. Two subsequent trips to the island also failed to discover any dead or sick deer. Therefore we do not believe, as do Hayes and Shotts (1959), that ice conditions contributed directly to the mass mortality. Furthermore, there had been fairly frequent freezes prior to 1955 without any report of excessive mortality coming to our attention.

PHYSICAL CONDITION

The deer collected from 1955 through 1960 were, with one exception (#1961), in excellent condition and appeared well nourished. All animals had moderate amounts of fat in the mesenteric and subcutaneous depots. Their musculature was, without exception, well developed with no evidence of emaciation. Their pelage was shiny and dense, not patchy, loose, or ruffled. Further, numbers 1959, 1960, 1963, 2451, 2452, and 2454 were as large as any males seen at the time of their collection. Indeed, in #2451 both hind legs had been shattered at the ankle joint, apparently by a shot well before collection. The animal was running on the exposed tibiae and yet appeared to be in excellent condition, wholly unimpaired by this degree of injury, as its body weight indicates (Table 3). Collections were made in the daytime when stomachs were full. The contents consisted largely of grasses, wax myrtle, and loblolly pine. We have noted one possible exception, #1961, to the otherwise apparently good condition of these deer collected at the time of the die-off. An effort was made to collect sick deer but this individual was the only one which was in obvious distress. It staggered, appeared weak, and its pelage was somewhat ruffled. Nevertheless, this animal was not emaciated nor in poor condition at autopsy.

Significant changes in the size of these deer were found from year to year in spite

of the good general appearance and a moderate amount of fat. A general decline in body size occurred between 1954 and 1958, followed by a sharp increase in 1959 and 1960 (Table 3). Since the condition and relative amount of fat remained constant, and since all deer had full rumens at autopsy, it is reasonable to assume that weight is an indicator of growth. The live weight of the males was 34 percent greater in 1960 than in 1958, including #2453 which weighed only 24.1 k. This deer was born in 1955 and therefore experienced the conditions of the die-off during its period of most active growth. The growth of a male born in 1954 (#2452) does not appear to have been inhibited. No does were collected in 1958, but those collected in 1960 were 28 percent heavier than the 1955 and 1957 females (Table 3). Body weights are obviously different, clearly indicating that growth of these deer was seriously impaired through 1958, but subsequently recovered.

The reproductive ability of the deer seemed unimpaired. All mature females collected (1955 and 1960) either were pregnant or lactating. The five embryos collected (three in 1955 and two in 1960) were viable and well developed. All mature males showed evidence of having undergone active spermatogenesis during the preceding rut. Sperm were found either in the testes and epididymes or in the epididymes only, depending on the date of collection. Therefore reproductive function apparently was normal in all samples.

No gross abnormalities of the abdominal or thoracic organs, brain, or pituitary were noted until 1960, when a mature male (#2452) had a grossly scarred liver and yellow body depot fat. The external surface of the liver was coarsely granular, the organ was resistant to cutting, and its normal color was mottled with yellow. The fat was less deeply yellow in the second male (#2454) and its liver was grossly normal. However, marked changes in the weights of the adrenals and the microscopic appearance of the adrenals, liver, and kidneys were found and will be discussed below. The sections of all other organs were essentially negative.

TABLE 3.—Weight of sika deer, *Cervus nippon*, and of their adrenals.

Date	Sex	Age	Weight	Status	Adrenal	Deer Number
			(*K*)		*mg/kg*	
December, 1952–54[1]	M	—	31.3	antlered	—	—
	M	—	29.5	"	—	—
	M	—	33.6	"	—	—
	M	—	28.6	"	—	—
	M	—	33.6	"	—	—
April, 1955	F	6+	23.6	1 embryo	10.5	1634
	F	2	19.1	1 embryo	14.3	1635
	F	2	19.5	1 embryo	9.3	1636
	F	4–5	23.2	lactating	8.7	1638
	F	1	11.4	immature	9.4	1637
					$\bar{x}$ = 10.7	
April, 1957	F	2	20.0	lactating	—	—
March 6, 1958	F	—	12.5	found dead	—	—
March 8, 1958	M	3	23.6	antlered	13.1	1959
	M	3	22.7	antlered	9.2	1960
					$\bar{x}$ = 11.2	
	M	1	8.2	immature	20.7	1961
	F	1	10.5	immature	17.4	1962
					$\bar{x}$ = 19.1	
February 13, 1959	M	3	34.5	antlered	8.8	1963
March 25, 1960	M	3–4	33.2	antlered	5.2	2451
	M	5–6	33.6	shed	7.4	2452
	M	3–4	32.7	antlered	5.1	2454
	M	4–5	24.1	antlered	6.4	2453
	M	1	15.0	immature	7.6	2455
					$\bar{x}$ = 6.0	
	F	2–3	27.3	1 embryo	5.8	2450
	F	2–3	27.3	1 embryo	6.5	2456
					$\bar{x}$ = 6.2	

[1] These data were supplied by the Maryland Game and Inland Fish Commission.

Detailed parasitological examinations were made in 1955 and 1958. Only gross examinations for parasites were made subsequently. The examinations were negative except for one female in 1955 which had nematodes in its lower colon.

HISTOLOGICAL DESCRIPTION

Adrenal glands: Changes in weight of the adrenal glands were associated with changes in population (Table 3). An increase occurred from 1955 to 1958, followed by a decline in 1960. Since there

is no difference in weight of adrenals from males and females the adrenal weights are combined for comparative purposes. Relative adrenal weights (mg/kg) remained relatively constant in mature deer from 1955 through 1958, at about 11 mg/kg, and dropped to about 6 mg/kg in 1960 (Table 3) a decrease of 46 percent from 1958 to 1960, associated with a decline in the population of approximately 60 percent. Adrenal weight in immature deer increased 78 percent from 1955 to 1958, and then declined by 1960 to 40 percent of the 1958 and 81 percent of the 1955 levels. Sample sizes were small, but the differences were marked and support one another. More specimens of immature animals from 1960 would have been desirable. It is notable that the deer with the heaviest adrenals in 1960 (#1952) also had cirrhosis of the liver, a condition commonly associated with adrenal hypertrophy.

These changes in adrenal weight with changes in population size are appreciably greater than has been observed in any other species. It is evident that changes in the population were associated with greater changes in the adrenal weights of young than of mature deer.

Differences in adrenal weight with respect to age, population, and hepatic disease were found, microscopically, to be due to differences in the amount of cortical tissue, particularly of the fasciculata-reticularis, although no consistent significant differences were observed from sample to sample in the appearance of the cells of these zones (Figs. 3A, 3B, and 3D). However, the appearance of the cortical *zona glomerulosa* changed significantly during the study (Figs. 3A–3D). The glomerulosa of all deer in 1955 was relatively free of cells exhibiting pycnosis (Fig. 3A). However, by 1958 and persisting through 1959 and 1960, there was a marked number of cells showing pycnosis (Figs. 3B and 3D) which probably was most striking in #1963 of 1959 (Fig. 3B). Such pycnotic nuclei suggest over-stimulation accompanied by cellular degeneration. The condition of the *zona glomerulosa* of the deer which had died in 1958 was identical to those from deer which were shot (Fig. 3B).

In 1958 a young animal (#1961), noted to be in a weak condition, showed marked degenerative changes in the glomerulosa characterized by necrosis of the cells with hemorrhage into cords, so that individual cords approached the appearance of blood sinusoids (Fig. 3C).

The adrenal medullas appeared normal in 1955 (Fig. 3E) but in 1958 were seriously altered by a marked irregularity in cell size and a striking number of pycnotic nuclei in the degenerating cells in the deer which were shot as well as in the one that had died, suggesting, as for the glomerulosa, over-stimulation with degeneration and repair. This appearance persisted but with some evidence of resolution in the medullae in 1959 (Fig. 3G), but a return toward normal was seen in all deer in 1960 (Fig. 3H).

Kidneys: Except for possibly a slight increase

Fig. 3A, B, C, and D of the outer *zona fasciculata, zona glomerulosa*, and capsule of the adrenals of sika deer, *Cervus nippon*, over a 6 year period, showing changes occurring before, during, and after the die-off. All × 212, H and E stain.

3A. #1635, typical of the appearance in 1955 and considered normal for the species. Note the general absence of pycnotic nuclei and cytoplasmic degeneration in the cells of the *zona glomerulosa*.

3B. #1963, illustrating typical appearance at the time of the die-off (1958) and the year after, including the deer found dead at the time of the die-off. Note the ragged appearance, often shrunken, and more deeply eosinophilic (darker) staining cytoplasm of the *glomerulosa* cells. Many of these have hyperchromic, irregular, often shrunken pycnotic nuclei. This illustration should be reversed.

3C. #1961. This immature deer was obviously in weak condition when shot at the time of the die-off. More advanced degeneration of the cells of the *zona glomerulosa* with several foci of hemorrhage are shown, suggesting over-stimulation.

3D. #2454, typifying the appearance of the adrenals two years after the die-off (1960). Degenerative changes are less marked than in 1958 and 1959, although pycnotic nuclei are still conspicuous.

Fig. 3E–H, a similar series of sections illustrating changes in the adrenal medulla before, during, and after the die-off, in the sika deer, *Cervus nippon*.

3E. #1635, illustrating the relatively normal apearance of the medulla typical in 1955.

3F. #1960, typical appearance of all deer examined at the time of the die-off, including the one which had died. Cellular degeneration with pycnosis is conspicuous; note the portion bordering the cortex in this section. Marked variations in cellular size suggest an active regenerative process as well as degeneration.

3G. #1963, shows evidence of recovery from the degenerative changes seen in 1958. Regeneration is indicated by the irregular nucleae and cell size, but evidence of active degeneration is largely lacking.

3H. #2450, typical appearance of medullas in 1960. Some evidence of degeneration and repair remains but, in general, the medulla appears normal.

in size the kidneys of these deer appeared essentially normal at autopsy. However, there were marked microscopic changes in the glomeruli.

The kidneys of two deer in 1955 (#1637, 1638) and all thereafter exhibited some degree of diffuse, non-exudative, proliferative glomerulonephritis. In its mildest form the disease was characterized by edema and swelling of the material in the intercapillary spaces (mesangium) of the tuft (Fig. 4B) compared to apparently normal or nearly normal glomeruli from 1955 (Fig. 4A). There was ischemia of the capillaries and partial collapse of the capillary basement membranes with restriction of their lumens. Some increase in the cellular elements of

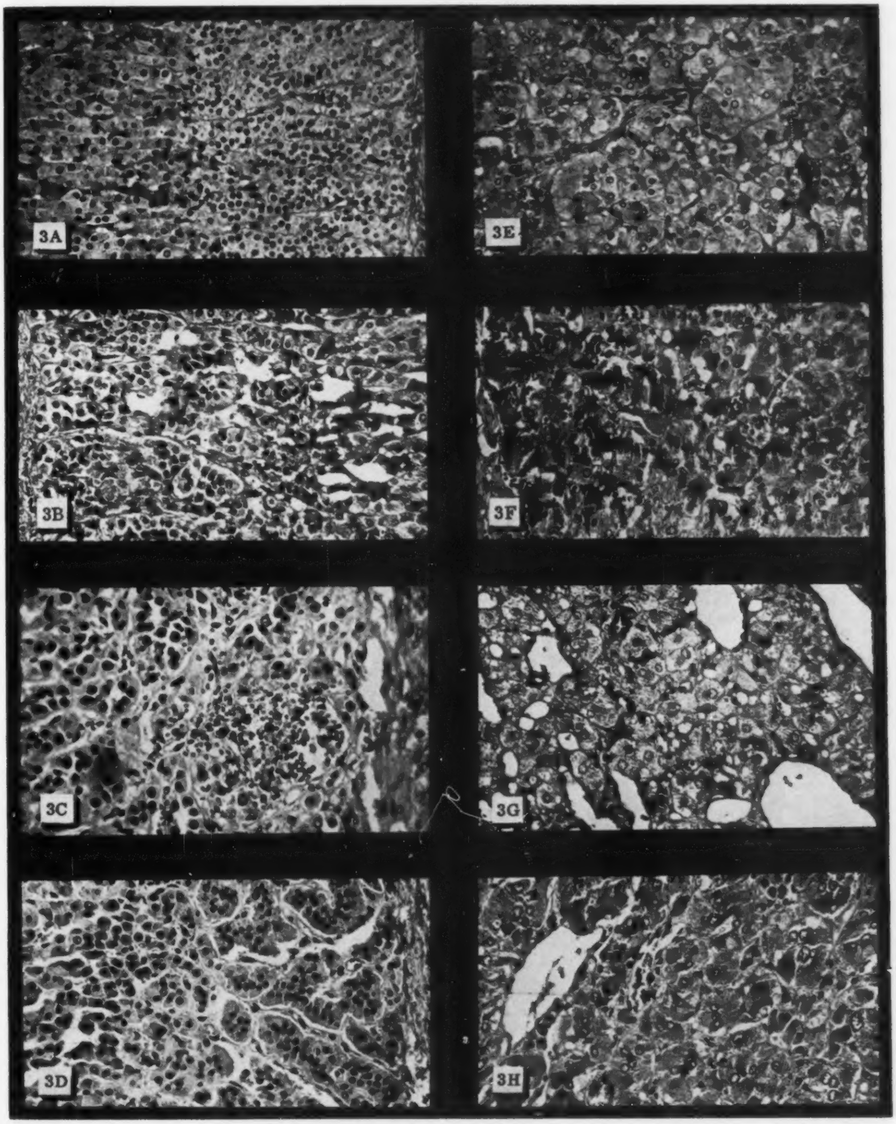

Fig. 3.

the mesangium and stalk was seen, especially in the periphery of the lobules, with distortion of the typical cloverleaf patterns of the capillaries. In more severe and probably more acute form these changes were all accentuated (Figs. 4C–4F). The capillary basement membranes generally were wrinkled and collapsed, frequently with total occlusion of the capillary lumens. Cellular hyperplasia was more marked and there was a marked deposition of PAS (Periodic Acid-Schiff) positive

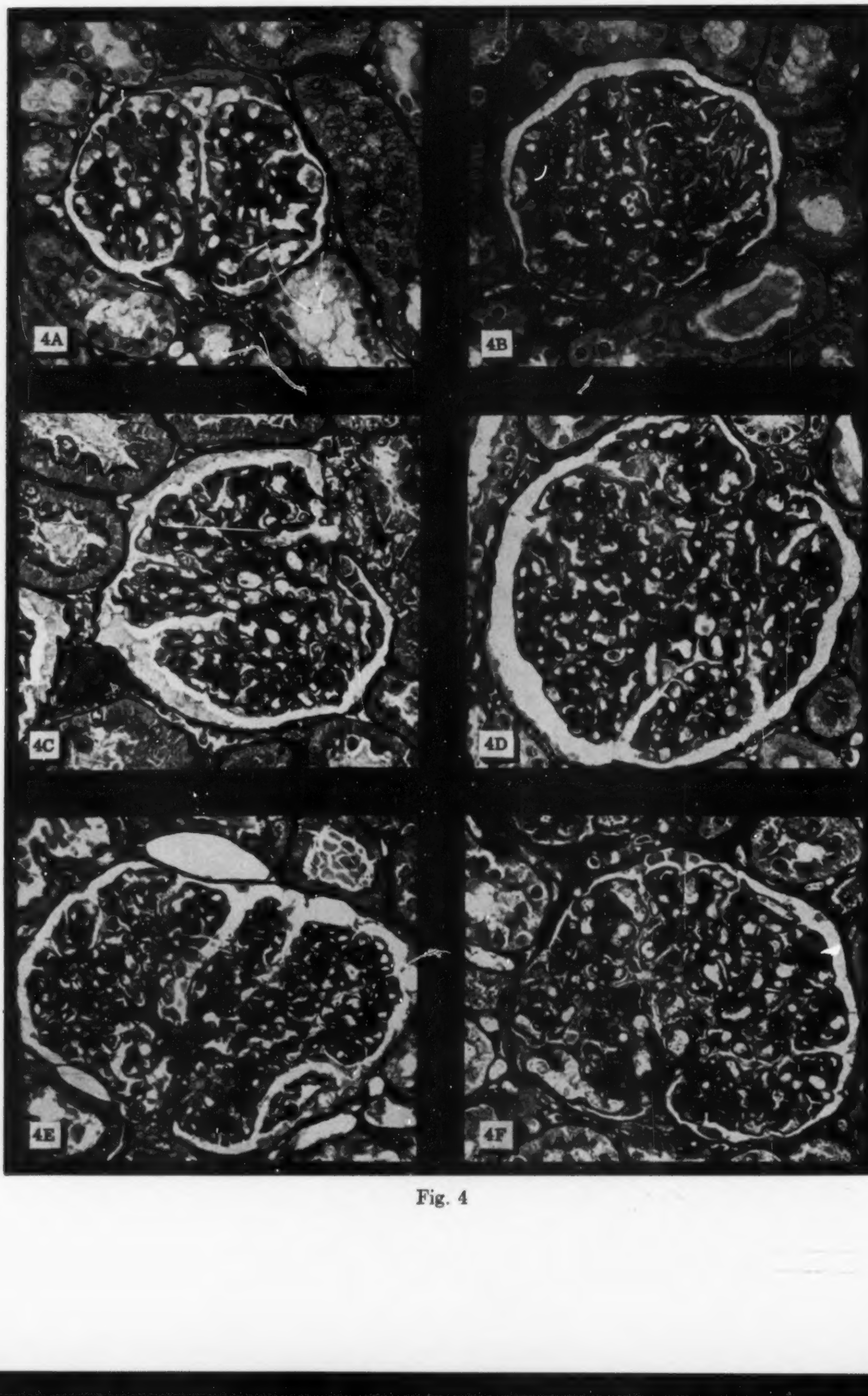

Fig. 4

fibrils in the mesangium, especially in the region of the bases of the capillaries. Infiltration by inflammatory cells or thickening of the capillary basement membranes was not observed. The presence of deeply eosinophilic, PAS positive casts in the lumens of many tubules, especially the collecting ones, indicated that the glomeruli were leaking protein. No epithelial crescents were observed. Adhesions between the tuft and Bowman's capsule were not seen. The changes seen in the glomerular structure of these deer are similar to those described for acute and subacute glomerulonephritis in humans (Grishman and Churg, 1957; Churg and Grishman, 1959) except for the absence of inflammatory infiltration and progression to a more severe form of the disease.

Involvement of the interstitial tissue and tubules was rare and evidently secondary to the glomerular changes, as it was observed only in the more severely involved kidneys. These changes assumed the form of occasional small foci of tubular atrophy associated with chronic inflammatory response, and were an inconspicuous part of the whole picture. This disease is notable for the general absence of an inflammatory response. In general, the tubules are entirely normal.

Juxtamedullary congestion was present in all deer shot.

Arteriosclerosis, characterized by moderate intimal proliferation in the larger arteries was seen in most of the more severely and apparently chronically involved kidneys (Fig. 6D). Arteriosclerosis also was present in a few of these.

The severity of the glomerulonephritis was graded on a basis of 1 to 5, 1 being entirely normal and 5 representing terminal, almost total destruction of the glomeruli. These gradings are given for each deer in Table 4. In 1955 the kidneys of only two deer (#1937, 1938) showed clear-cut involvement of the glomeruli (Fig. 4B). In these the glomerular tufts showed primarily an acute edematous glomerulonephritis with an increase in PAS negative intercapillary substance. In subsequent years the decrease became more pronounced with increased proliferation and scarring of the tufts (Figs. 4C–4F). The most severe subacute form of the disease was observed in the deer shot in 1959 (#1963) (Fig. 4E). All of the deer shot in 1960 showed renal disease even though some were not old enough to have experienced the population collapse (Fig. 4F), and the kidneys of #1961 which had been in weak condition in 1958 were not so

Fig. 4A–F illustrate the changes seen in the renal glomeruli of these sika deer, *Cervus nippon*, from 1955 through 1960. Renal tubules also are shown around the glomerulus in each figure. The normal appearance of the tubules is apparent irrespective of the changes in the population or degree of glomerular involvement. All sections 3 micra thick and stained by the allochrome method.

4A. #1637. Apparently normal glomerulus from an immature female in 1955. The renal glomeruli in three of the five deer shot in 1955 presented this appearance. Note the full expansion of the glomerular capillaries, the relative lack of intercapillary substance, and the lack of increased cellularity in the tuft in spite of it being an immature animal. However, note the pycnotic nuclei of the juxtaglomerular cells. × 440.

4B. #1638. Illustrates the glomerular disease as it was first observed in two deer in 1955. Cellularity is not increased noticeably, but a conspicuous increase in intercapillary substance with some wrinkling of the basement membranes of the capillaries and partial collapse of the capillary loops resulting in restriction of the lumens and an associated ischemia. These changes have been attributed to edema of the tuft in an early acute stage of glomerulonephritis (Grishman and Churg, 1957). However, since inflammatory cells are lacking the changes observed here perhaps more closely resemble those of nephrotic (non-exudative) glomerulonephritis. × 440.

4C. #1950. Illustrates more advanced glomerular changes in a mature female seen in 1957. Note the marked increase of cellularity of the mesangium with further restriction of the capillary loops and folding of the capillary basement membranes as compared to Fig. 4B. × 440.

4D. #1960. Renal glomerulus from a mature male at the time of the die-off. There is a marked increase in cellularity, especially in the mesangeal cells, with an increase in PAS positive fibrils (dark staining) in the intercapillary substance. Many capillary loops are almost totally occluded. Similar changes were seen in the deer which died, but they were less pronounced, especially the loss of potency of the capillary loops. × 440.

4E. #1963. Deer shot in 1959. All of the changes seen in 1958 (Fig. 4D) are present here, but scarring of the tuft, as indicated by the increase in PAS positive fibrils in the intercapillary substance is somewhat more pronounced. × 440.

4F. #2454. Illustrates the typical appearance of glomeruli in the deer in 1960. Changes in the glomerular tufts resemble those seen in the preceding year (Fig. 4E) except for the more open capillary loops. The tuft does not present the condensed appearance of the one preceding. However, scarring and increased cellularity of the tuft is prominent. These changes suggest a return of more normal function following severe involvement. Note the precipitate in Bowman's space. × 360.

TABLE 4.—Pathologic condition of adrenals, kidneys, and livers of sika deer, *Cervus nippon*.[1]

Deer Number	Adrenals		Kidneys					Livers			
	Pycnosis in glomerulosa	Casts	Inflammatory foci (atrophied)	Pycnosis	Arteriosclerosis	Arteriolosclerosis	Glomerulonephritis	Glycogen	Inclusions	Clefts	Severity of disease
1634	—	—	—	—	—	—	1.5	2	—	—	1
1635	—	—	—	—	—	—	1.5	2	—	—	1
1636	—	—	—	—	—	—	2.0	2	—	—	1
1638	—	1	—	—	—	—	2.5	2	—	—	1
1637	—	—	—	—	—	—	1.5	2	—	—	1
1950	—	1	—	—	1	—	2	—	—	—	—
1959	1	1	—	—	—	1	2.5	1	2	2	3
1960	1	1	1	—	—	—	3.0	1	2	1	3
1961	2	1	—	—	—	2	2.5	2	1	1	2
1962	1	—	—	—	—	1	2.5	1	1	2	2
1963	3	2	2	—	—	—	3.5	1	1	2	4
2451	1	1	—	1	2	1	2.5	1	2	2	3
2452	1	1	2	—	1	1	3.0	1	3	2	5
2454	1	1	—	—	2	2	3.0	1	4	2	4
2453	1	—	1	1	1	—	2.5	1	2	1	2
2455	1	—	1	—	—	—	2.5	1	1	2	2
2450	1	2	1	1	1	—	3.0	3	1	2	2
2456	1	1	—	—	2	—	2.5	4	1	1	2

[1] Grading of the severity of renal disease is on a basis of 1 to 5, where 1 is normal and 5 essentially total glomerular destruction. Renal grading is based on a scale established from other species. Hepatic disease is graded 1 to 5 where 1 is normal for the total series of these deer and 5 the most severe seen within this series.

severely involved as were those in later years. Except for a moderate degree of terminal passive congestion, the kidneys of the deer which died in 1958 resembled the others from that year, even with somewhat less severe glomerulonephritis. There appeared to be some return of circulation through the glomerular capillaries in 1960 (Fig. 4F), suggesting the beginning of resolution of the disease, although there was still a reasonably severe subacute or chronic glomerulonephritis. It is clear that these deer suffered from a chronic nonexudative, proliferative, intercapillary glomerulonephritis which began to make itself known in 1955, increased in prevalence and severity until 1958 (at the time of the die-off), and persisted for the following two years with an increase in severity, but showed some signs of resolution in 1960. This disease became evident at least three years prior to the die-off and continued for at least two years afterwards.

Liver: In 1958 hepatitis first appeared in the livers of the deer, those which were shot as well as in the one that died. This disease was characterized by active periportal necrosis and regeneration with cellular enlargement, and by the presence in many parenchymal cells of eosinophilic intranuclear inclusions closely resembling those seen in the cytomegalic inclusion disease of the renal tubules of urban rats (Figs. 5B, 5H and 6C). The presence of peculiar intracytoplasmic, semilunar clefts (Figs. 5B–5H and 6A–6C) in paraffin sections of the parenchymal cells was also characteristic. However, frozen sections showed these clefts to be refractile, yellowish, curved, double tapering rods which failed to take either nuclear or Sudan IV stains. Evidently the rods were soluble in one or more of the organic solvents used to process paraffin sections, but not in water. The clefts were largest and most conspicuous in the areas of the hepatic lobes uninvolved in the clearly acute phase of the disease, and were much smaller, more abundant, and less easily distinguishable in necrotic cells (Figs. 5B, 5F and 5H). None of these livers gave evidence of inanition. This statement is based on the lack of shrunken, deeply staining parenchymal cells with a loss of glycogen and cytoplasmic nucleic acid.

The intranuclear inclusions varied considerably in size and form and were more common in the periportal areas. The variations in the morphology of the inclusions are comparable to those described by Randall and Bracken (1957) for experimental hepatitis in hamsters, produced by equine abortion virus. They were eosinophilic, PAS negative, granular, round bodies producing margination of the chromatin and stained very pale blue with the allochrome stain. There was rarely more than one per nucleus.

Frozen sections stained with Sudan IV showed that intranuclear fat globules often, but not always, were associated with the inclusions. The fat globules varied from one to 20 or more per nucleus, but occurred in not more than a quarter of the cells.

Fat stains on frozen sections also showed that fatty degeneration of the hepatic cells was extremely rare, being found only in one small focus of one liver (#1963). What appeared to be fat vacuoles in some of the parenchymal cells in standard preparations did not stain for fat in frozen sections. The livers of mature males became much more severely involved than did those of mature females or immature deer, but this may have been partly due to age (Table 3). The liver of the male shot in 1960 (#2452, Fig. 5G), showed marked bile duct proliferation associated with a gross appearance of cirrhosis.

Hepatitis was not apparent in the deer in 1955 (Fig. 5A). At that time the livers contained moderate glycogen, roughly periportal in distribution, although the hepatic cells were shrunken and the blood sinusoids dilated.

The livers in 1958 showed a moderate degree of hepatitis, although inclusions were less common and the degree of degeneration and repair was less than that seen subsequently (Figs. 5C and 5D). However, there was pronounced cytomegaly and variation in nuclear size in involved areas (Fig. 5C). Little or no inflammatory response was seen. The intracytoplasmic clefts were conspicuous at this time. The level of glycogen in the 1958 animals

was somewhat reduced from the 1955 levels, but still present (Table 3).

The liver of the 1959 male (#1963) presented the most acutely involved of any (Fig. 5E and 5F). There was active necrosis and regeneration in the periportal areas, with marked enlargement of the cells and all stages of nuclear dissolution. Intracytoplasmic, semilunar clefts seldom were found in these acutely diseased cells, and glycogen was wholly lacking. Frozen sections showed no fat in the cytoplasm or nuclei of these cells, although intranuclear fat globules were present in many of the cells with clefts. Glycogen was present in the liver as a whole, in reduced amounts.

In 1960 the degree of involvement of the livers of mature males was obviously greater than in 1958, although less acute than in 1959. Table 4 and Figs. 5G–5H and 6A–6C summarize the results in 1960. Again, mature males were more severely involved than were does or young. Inclusions were most abundant in these deer and intranuclear fat vacuoles were conspicuous (Figs. 5H and 6C). All of the elements previously noted were seen in these deer, and in addition there was frank proliferation of the bile ducts of male (#2452) (Fig. 5G).

The lungs, GI tracts, and other organs were essentially negative except for a marked reduction in the lymphoid elements of the spleens of all animals (Figs. 6E and 6F).

Discussion

Ten years ago it was postulated that the growth and declines of mammalian populations might be controlled by physiological responses to population density (Christian, 1950). The importance of the pituitary-adrenocortical and pituitary-gonadal systems was stressed at that time. Since then considerable evidence has been collected from the laboratory and from natural populations to support this hypothesis, and it has been shown that social pressures (intraspecific competition) associated with increased density are the primary stimuli to increased activity of the physiological adaptive responses (Christian, 1959). It should be emphasized for the present purposes that these responses also result in decreased resistance to disease (Christian and Williamson, 1958; Davis and Read, 1958) and may play an important role in the production of other diseases of obscure etiology.

The data on this herd of sika deer present a number of questions, as well as provide some answers and a basis for tentative conclusions regarding several population factors.

This herd reached a density of one per acre sometime before 1955, then in two months of the winter of 1957–58, 60 percent died. The decline in population continued at a slow rate for another year, then the population began to increase again.

It often is stated that the decline in protein content of browse on winter range is critical (Longhurst *et al.*, 1952; Swank, 1956). However, the fact that the protein requirements of deer in good condition also decline (McEwen *et al.*, 1957) cast a considerable doubt on these conclusions. In terms of fat, glycogen, musculature, and general appearance the nutritional status of these deer was good and remained so with changes in the size of the population. In view of the present evidence the conclusions of Hayes and Shotts (1959) that malnutrition was an important factor contributing to the die-off of these deer seem untenable; so also does their statement that freezing of the mainland passage contributed to the development of malnutrition.

Disease often is said to be a major factor in population die-offs, but in this case disease could not have been a serious cause. Two diseases occurred in these deer—glomerulonephritis and inclusion hepatitis—but the history of each casts doubt on the possible role of either in the die-off. Hepatitis was first observed at the time of the die-off; it may have been present earlier but samples are not available to check. However, the hepatitis was relatively mild in 1958 and increased in severity in 1960. The available material suggests that this was a chronic, relatively mild hepatitis which would have been a factor in mortality only very late in its course, by the production of severe post-hepatitis cirrhosis. The data indicate that deer acquire the disease early in life and henceforth progresses slowly—probably a matter of years—to result eventually in a frank post-hepatitis cirrhosis. In no instance was cholemic nephrosis seen in association with the hepatitis, although there was a sufficient retention of blood pigments in numbers 1952 and 1954 to stain their adipose tissue yellow. There is no evidence to suggest that the hepatitis was severe in 1958, or that it directly contributed to mortality. The conclusion is

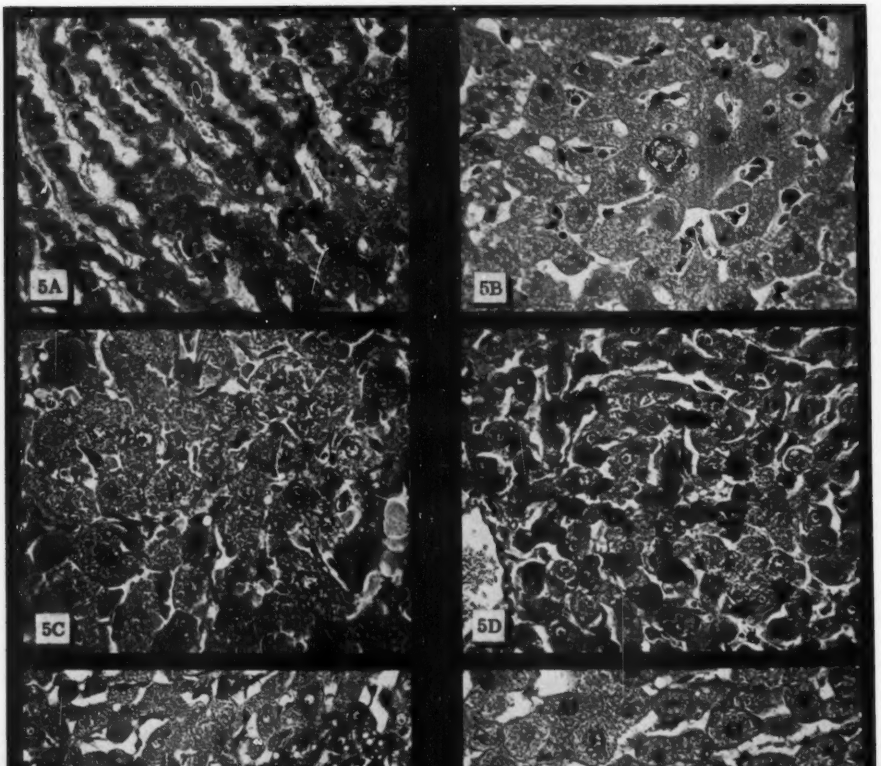

Fig. 5.

supported by deer #1961, which appeared on the verge of collapse, yet had only a mild involvement of the liver (Fig. 5D).

Glomerulonephritis was first seen in mild form in some deer in 1955. It increased in severity through 1959, and remained severe through 1960. However, in no instance did it appear sufficiently severe to result in renal failure, although there was protein loss. Other studies on wild and captive mammals indicate that social strife is associated with the appearance of a similar glomerulonephritis (Christian, 1958 and unpub.) which may be associated with altered adrenocortical and other metabolic functions associated with increased density and strife.

It appears that neither renal nor hepatic disease contributed significantly to mortality. Indeed, it is much more likely that both of these diseases stemmed from altered metabolic factors concomitant with high population densities, which may play an etiologic role in the case of the renal disease and seriously lower resistance to infection in the case of hepatitis, as both diseases were much more serious a year or more after the die-off than at the time of its occurrence.

Hayes and Shotts (1959) have suggested that excessive browsing on pine, with the formation and absorption of pine oils, was responsible for the die-off by (1) direct toxicity and (2) sterilization of the rumen and consequent malnutrition. This diagnosis is unlikely for the following reasons: (1) the general well-fed appearance of the deer,

Fig. 5A–H illustrate conditions in the livers of sika deer, *Cervus nippon*, from 1955 through 1960, showing the inclusion hepatitis and its development from 1958.

5A. #1638. Typical of the livers in 1958. The cells are somewhat shrunken and the sinusoids dilated in that year, a condition not noted subsequently. Note the uniform size of the nuclei and the presence of glycogen in the cytoplasm (appearing as black material in this photograph). Allochrome. × 360.

5B. #1960. Liver of a 1958 deer with acute hepatitis. Note the large granular eosinophilic inclusions in the nucleus in the center of the field as well as bizarre chromatin pattern in some of the other nuclei. The liver cells are enlarged and the nuclei have almost disappeared from many. The beginnings of small semilunar clefts may be discerned in the cytoplasm, especially of the more peripheral cells. They appear to be absent from the cells in the center of the field which seem to be undergoing active degeneration. H and E. ×360.

5C. #1960. Another field from the same section showing an area of less active degeneration. Darkly staining glycogen is present in the cytoplasm of many cells, the nuclei appear more nearly normal, and semilunar clefts in the cytoplasm are much larger and more conspicuous. One forms the impression that these less acutely involved cells may represent recovery from an active process. The appearance of the liver from the deer that died was essentially similar throughout to the condition shown in this figure. Allochrome. × 360.

5D. #1961. Shows the comparatively normal appearance of the liver from the immature deer which appeared near collapse in 1958. There is some evidence of degenerative change, but is minimal compared to the preceding. Glycogen is abundant. Allochrome. × 360.

5E. #1963. This liver from 1959 clearly had the most acute hepatitis of any seen. Note the nuclear vacuolation produced by fat. The cytoplasmic vacuolation shown was negative for fat. Semilunar clefts and necrotic cells are seen in this field. In spite of these alterations, glycogen is moderately abundant. Allochrome. × 212.

5F. Same deer. Active degeneration and regeneration are seen as well as an abundance of cells containing conspicuous clefts. H and E. × 360.

5G. #2452. This liver from 1960 appeared grossly scarred and body and depot fat was deeply yellow. In addition to an active hepatitis, there is marked proliferation of the bile ducts. This liver had the appearance of having been involved in a chronic hepatitis of considerable duration. Degenerating and regenerating cells may be seen. H and E. × 212.

5H. #2454. This liver from a mature male shot in 1960 had more inclusions and a more acute hepatitis than any other seen during that year. Large and small intranuclear inclusions of two types may be seen, as well as intranuclear fat vacuoles. The latter are perfectly clear, whereas the inclusions are pale grey (large), dark grey (small), or appear mottled. Aberrant chromatin patterns, semilunar intracytoplasmic clefts, and cells undergoing necrosis also are present. The fat of this deer also was stained yellow, but less deeply than in #2452. Allochrome. × 360.

including an obviously weak one, (2) evidence that the degree of browsing on pine had not changed from periods before and after the die-off, (3) the absence of renal tubular lesions (Smith and Jones, 1957), (4) the absence of lesions in the liver consistent with poisoning by organic compounds, and (5) by the amount of pine bark or leaves which would have to be ingested in the winter to produce toxic amounts of pine oils, when it is considered that 3–15 cc of turpentine is the medicinal dosage for sheep (Stecher, 1960).

Factors correlated with changes in the population were growth, antler development, and changes in the adrenal glands. A remarkable decline in adrenal weight, representing a decline primarily in the

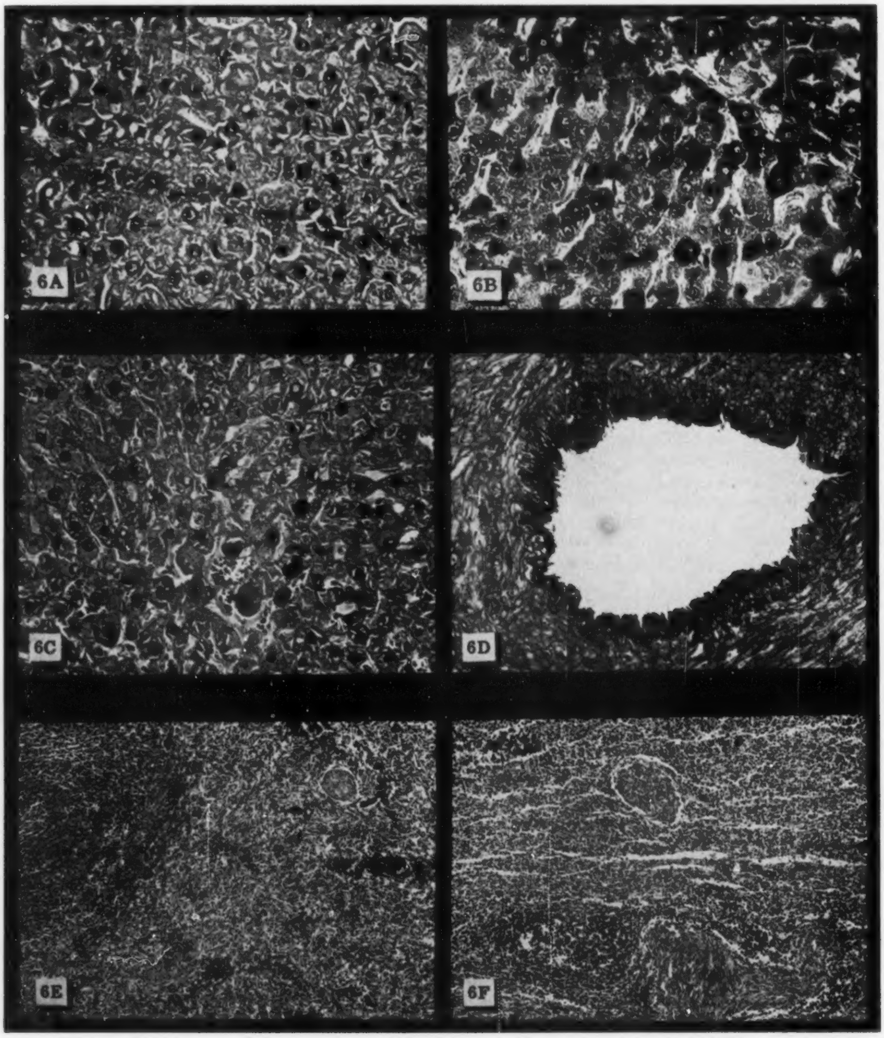

Fig. 6.

amount of adrenal cortical tissue, was seen after the die-off. Also, adrenal weight increased, particularly in the immature animals, from 1955 to the winter of 1958, and the subsequent decline was more marked than it was in the adults. These results coincide with those from other species in which a positive correlation between adrenal weight (as an index of cortical function) and population density has been shown, except that the magnitude of the response in deer is greater than had been observed heretofore. Inhibition of growth in association with increased pituitary-adrenocortical function is now well-established and is due, in part, to the growth inhibitory action of the corticoids, probably in part by inhibition of secretion of growth hormone from the pituitary (Christian, 1961).

The adrenal weight of male #2452 was greater than that of the others from the same sample, which is consistent with the presence of hepatic cirrhosis (Bloodworth and Sommers, 1958).

The marked pycnosis and apparent hyperplasia of the adrenal *zona glomerulosa* from 1958 through 1960 is not thoroughly understood. These changes suggest severe stimulation with active degeneration and regeneration. The glomerulosa secretes aldosterone, which regulates electrolyte fluid metabolism, and the secretion of aldosterone is stimulated by increased potassium, a fall in blood volume or, to a much lesser degree (and only for short periods) by ACTH. Therefore there is a suggestion in the morphological appearance of the glomerulosa that from 1958 on there were chronic fluid-electrolyte disturbances in these animals. Possibly the appearance of the glomerulosa reflects fluid and electrolyte disturbances in association with glomerulonephritis. The persistence of these changes in the glomerulosa through 1960 would be compatible with such an interpretation. Little can be said further except to note that the one animal (#1961) which, in 1958, appeared on the verge of collapse, had "tubule formation" with hemorrhage of the *zona glomerulosa*, suggestive of extreme stimulation. The behavior of this animal would be compatible with acute adrenal insufficiency and electrolyte disturbance.

The cellular degeneration, degranulation, pycnosis, and variability in size of the adrenal medullas in 1958 suggest active degeneration and regeneration, resulting from excessive stimulation.

Hayes and Shotts (1959) reported degeneration of the medulla in the deer they examined, which had succumbed during the die-off. This condition was not noted in 1955, 1957, or 1960, and was only slightly evident in 1959, suggesting recovery. Therefore there is evidence of a marked increase in sympatho-adrenal activity in 1958. It has

Fig. 6A–C. Further illustrate conditions in the livers of sika deer, *Cervus nippon*.

6A. #2455. This liver of an immature male shot in 1960 showed less severe involvement than the two preceding livers. However, intranuclear fat vacuoles and intracytoplasmic clefts may be seen. Inclusions, although present, were not common. A small inclusion may be seen in the upper right corner of the field. The darker staining cells contain glycogen. The livers of numbers 2451 and 2453 appeared essentially identical to this except for a much greater number of inclusions. Allochrome. × 360.

6B. #2456. The liver of a pregnant female shot in 1960. Relatively mild hepatitis with the formation of clefts. The marked abundance of glycogen is shown by the darkly staining cells. The liver of the other pregnant female from 1960 (#2450) was similar. Allochrome. × 212.

6C. #2454. A lower power photomicrograph of the same liver as shown in Fig. 5H, to illustrate the abundance of inclusions, variability in cell and nuclear size, and the wide distribution of clefts. These last are particularly noticeable in the smaller and seemingly less actively involved cells. H and E. × 212.

6D. #2454. A typical illustration of the relatively mild arteriosclerosis, characterized by intimal proliferation, seen in the larger renal arteries of a sika deer, *Cervus nippon*, in 1958, and many in 1959 and 1960. Allochrome. × 118.

6E and F. Spleens of sika deer from 1958 (numbers 1959 and 1962). Both show a marked reduction of the lymphoid elements in contrast to the amount one expects in a deer spleen. The spleens maintained this appearance from 1955 through 1960, perhaps somewhat more marked in the last year. H and E. × 85.

been established that physiological stress can result in a marked increase in the secretion of epinephrine and norepinephrine (Elmadjian *et al.*, 1958) and it is suggested that excessive sympathico-medullary stimulation and exhaustion, accompanying increased adrenocortical activity resulting from social competitive factors may have played a leading role in the die-off of these deer.

It is worth mentioning the diagnosis of malnutrition by gross inspection of the long-bone marrow at this juncture.

Loss of fat and gelatinous appearance of the marrow of long bones often is considered diagnostic of malnutrition in deer (Cheatum, 1949). However, there is reason to doubt the specificity of the disappearance of fat from the marrow. It is likely that any condition characterized by a negative nitrogen balance and loss of fat elsewhere can produce a fat-free, gelatinous appearance of the marrow. The marrow was examined in only two of the sika deer collected, therefore cannot be evaluated. However, changes similar to those ascribed to malnutrition frequently have been observed in the marrow of well-fed captive mammals. For example, at the Philadelphia Zoological Garden a barasingha deer and a white-tailed deer, each with quantitatively and qualitatively adequate food intake, died in extremely poor condition. They were wasted and their marrow was gelatinous with no fat. Both of these animals were subordinate males in their respective herds and were constantly subjected to attack and mistreatment, and, in fact, both were killed by the dominant male. These histories are typical for subordinate animals in penned groups. The value of the marrow as a specific diagnosis of malnutrition is open to serious question, unless one defines malnutrition in terms of basic anabolic-catabolic balances rather than in terms of food intake.

Malnutrition, pine-oil poisoning, and disease have been eliminated as important factors in causing the decline in size of the deer in this herd and their die-off in 1958. However, the data lead to the conclusion that adrenocortical, sympatho-adrenal, and other metabolic responses known to occur in increased density (therefore social strife) are primarily responsible for the die-off of the deer. Disturbed electrolyte and fluid metabolism may have been a part of this picture. The glomerulonephritis and helatitis described, more than likely are results rather than causes of the changes taking place in the population, and in the adaptive physiology of the deer.

Summary and Conclusions

The sika deer, *Cervus nippon*, introduced onto James Island, Maryland in 1916 had reached a population size of 280–300 by 1955, a density of one per acre. Sixty percent of the herd, primarily females and young, died in January-February, 1958. A further decline of 18 percent from the 1958 level occurred in 1959. A study of these deer was begun in 1955 in anticipation of the die-off, and continued through 1960.

All deer appeared well nourished and free of parasitism throughout the study, although there was a marked inhibition of growth at the time of the die-off, which primarily affected those in their first three years of age. Recovery of normal growth occurred following the die-off. Adrenal weight was high from 1955 through early 1958, and had declined 50 percent by 1960. Adrenal changes were more pronounced in young than in adults, which may be explained by behavioral-dominance factors. Beginning in 1958 and continuing through 1960, degenerative changes were seen in the adrenal *zona glomerulosa*, suggestive of over-stimulation. These changes may have been associated with some disturbance in fluid-electrolyte balances. The adrenal medulla showed marked degenerative changes suggestive of sympatho-adrenal over-stimulation, at the time of the die-off, with recovery in subsequent years.

A diffuse, non-exudative, proliferative, intercapillary glomerulonephritis is described. This disease began to make its appearance in 1955 and by 1958 involved all deer. Its peak evidently was reached in 1959, although all deer in 1960 were involved. At no time did this disease appear severe enough to be the direct cause of mortality.

A chronic, apparently viral, inclusion hepatitis, involving all deer collected, was first seen in 1958, but reached greatest

severity in 1959–1960. Its severity appears to have been related to the age of the deer —the older the more severe—and may affect males more than females. The history of this disease suggests that reduced resistance at the time of the die-off and peak population density accounts for its appearance. It was clearly not a cause of the die-off.

Malnutrition appears not to have been a factor in producing the decline of these deer, nor does toxic poisoning.

It was concluded that physiological disturbances, induced by factors associated with high population density, probably hierarchial-behavioral, were responsible for the deterioration and death of these deer, as well as for the manifestations of glomerulonephritis and hepatitis. These disturbances appear to be closely related to adrenocortical and sympatho-adrenal function.

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A Study of the Comparative Efficiency between Nylon and Linen Gillnets[1]

ROBERT J. MUNCY

ABSTRACT

Field tests were conducted during the spring of 1959 to compare the differences in the catches of soft-rayed fishes by synthetic (nylon) fiber and natural (linen) fiber gillnets. Test nets were matched as closely as possible from commercial net sources and each section was located randomly as to sequence of mesh size and material.

American shad (*Alosa sapidissima*), glut herring (*Alosa aestivalis*), and alewife herring (*Alosa pseudoharengus*) were the only species caught in sufficient numbers for comparisons between nets of different fibers. Analysis of the catches of American shad revealed differences in the numbers, length-frequency and length-weight of fish from nylon and linen gillnets.

Nylon anchor gillnets caught twice as many American shad as were caught in linen anchor gillnets of the same length and mesh sizes. Also, male American shad taken from nylon nets were heavier than those taken from linen nets. Although statistical comparisons were not possible with the small number of American shad caught in drift gillnets nor with the small number of herring caught in anchor gillnets, the greater numbers of fish were taken in nylon nets.

Introduction

Differences in efficiency of gillnets constructed from natural and synthetic fibers raise important fisheries management and research questions. The Maryland Fishery Management Plan was established to stabilize the number of fishermen and the gear usage in Chesapeake Bay at the 1940 level of fishing effort, according to Tiller (1944: 1–6). In addition, total catch and effort data have been secured from the licensed fishermen. Changes in efficiency as the result of changes in netting materials would affect the stability of fishing effort as well as the use of catch data for determining fish populations, natural mortality and fishing mortality.

Netting materials used prior to and during 1940 consisted entirely of natural fibers (cotton and linen). The increased structural strength and resistance to rot of some synthetic fibers, particularly nylon, has resulted in their adaptation for netting materials. Atton (1955:18) states that the use of nylon gillnets in Saskatchewan, Canada, first became common in 1950. The widespread acceptance of nylon netting by fishermen has resulted in the discontinuation of cotton gillnets and the necessity of special orders for linen gill netting.

Several studies on the structural characteristics of various net fibers have demonstrated the advantages and disadvantages of such materials Starr (1957:90), Brandt (1957:182–210), Miyamoto (1956:267–9), and Nomura and Nozawa (1955:762–9). In general, the characteristics given in these papers for nylon nets as compared to natural fibers were: increased resistance to rotting and internal wetting, increased resistance to fouling and attaching animals, increased strength and elasticity, resistance to abrasion; decreased resistance to sunlight and heat, and decreased visibility; varying resistance to chemicals; variable specific gravity and hardness of thread. Selection of different synthetic material or differences in processing permits the attainment of structural advantages which are not available with natural fibers.

In addition to studies on structural characteristics, several papers have been written

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on experimental netting tests between nylon and natural fiber nets, and they include: Atton (1955:18–26) and Molin (1951:59–65). Papers dealing with comparisons of catch data from nets of the two types of fibers include: Hewson (1951:7–9), Lawler (1950:22–4), Peterson (1952:18), and Ridenhour and DiCostanzo (1956:700–4). Other publications that put forth statements of increased efficiency of nylon netting under certain circumstances without citing actual field or experimental data include: Commercial Fisheries Review (1955: 68–9), Commercial Fisheries Review (1956: 55), Miyamoto (1956:267–9), and Starr (1957:90).

The advice and assistance in the field of Mr. Harry Jobes and Dr. Richard Whitney of the Susquehanna Fisheries Study greatly facilitated the completion of this phase of the net evaluation problem. Appreciation is also expressed to Mr. George Murphy for assistance rendered in preliminary field work. Suggestions of Dr. Whitney and the Chesapeake Biological Laboratory Editorial Board were extremely helpful.

Standardization of Gear

In the present study, all possible means were taken to standardize the gillnets made of nylon and linen fibers to reduce sampling bias. Anchor gillnet sets were constructed of eight 40-foot sections (106 yards) of linen and nylon gillnets of various mesh sizes. The mesh sizes used in the anchor nets were 3½, 4, and 5 inch stretch mesh (S.M.). Locations of paired mesh sections (nylon and linen) of the same mesh size were selected by random numbers, then the sequences of materials were located within the mesh location at random. For example, set number one was constructed of the following 40 foot sections: 4″ linen, 4″ nylon, 5″ linen, 5″ nylon, 3½″ nylon, 3½″ linen, 5″ nylon, and 5″ linen. Thread sizes of linen (30/3 cord = 0.30 mm) and nylon (#104 Barbour nylon = 0.25 mm) were selected so that diameter of threads would be matched as closely as possible from commercial netting. Each 40-foot section of linen and nylon netting was hung with the same size and number of rings and floats (every 5 feet). All anchor gillnet sections were made to hang eight feet deep.

The drift gillnets were ordered as 5½″ S.M., 30 mesh deep, nylon and linen nets. Upon receipt, it was found that the nets had been constructed 5½″ S.M., 40 meshes deep and the length shortened accordingly. This seriously limited the areas in which there was sufficient depth for these nets to be used at the head of Chesapeake Bay. Nylon and linen netting were ganged randomly by 100 foot sections. Actual construction of 5½″ S.M., 40 mesh drift gillnet was as follows: 100 feet nylon, 100 feet linen, 37 feet nylon and 180 feet linen. Thread diameters of nylon (#69 = 0.21 mm) and linen (40/3 = 0.24) were matched as closely as possible from commercial netting stock.

Results

Soft-Rayed Fish Caught in Nylon and Linen Gillnets

The catch consisted of the following soft-rayed fish: glut herring (*Alosa aestivalis*), alewife herring (*Alosa pseudoharengus*), American shad (*Alosa sapadissima*) and menhaden (*Brevoortia tyrannus*). Menhaden were usually caught with the net strands in their mouth and not "gilled" in the usual manner. For this reason, menhaden were not considered in the comparison. Catches of herring and American shad will be considered separately.

American Shad: Comparisons of the number of American shad taken in randomly-paired, matched nylon and linen 40 foot anchor gillnet sections revealed several differences between catches in the two net fibers (Table 1). Considering the different mesh sizes as separate trials on the seven days that all mesh sizes caught American shad, there were 21 tests between the catch of linen and nylon gillnets. In 20 tests, nylon nets caught more fish and in one test both caught equal numbers. If the probability of catches in nylon gillnets being equal to or greater than linen gillnet is considered one-half, then the probability of catch in nylon nets exceeding catches in linen nets in 20 out of 21 instances is $[(\frac{1}{2})^{21} + (\frac{1}{2})^{20} \cdot (\frac{1}{2})^{1}]$ or 0.00001. Thus the proba-

TABLE 1.—American shad catches in matched sets of linen and nylon anchor gillnets.

Date 1959	Stretch Mesh Size (inch)	No. Feet	Sex	No. caught in net of each fiber	
				Linen	Nylon
April 16	5	80	Male	1	1
April 30	3½	120	Female	0	1
	4	240	Male	2	5
			Female	0	2
	5	240	Male	2	4
			Female	1	6
May 1	3½	120	Male	0	4
			Female	1	0
	4	240	Male	3	3
			Female	0	2
	5	240	Male	2	2
			Female	0	4
May 8	3½	120	Male	0	1
	4	240	Male	0	1
			Females	0	1
	5	240	Male	1	1
			Female	4	4
May 9	3½	280	Male	1	4
			Female	1	2
	4	280	Male	1	8
			Female	3	4
	5	320	Male	2	8
			Female	7	23
May 10	3½	280	Male	1	1
			Female	0	4
	4	280	Male	3	14
			Female	2	7
	5	320	Male	6	7
			Female	7	25
May 19	3½	280	Male	0	2
	4	280	Male	5	9
			Female	0	2
	5	320	Male	3	19
			Female	5	3
May 21	3½	280	Male	0	2
			Female	1	1
	4	280	Male	6	20
			Female	0	1
	5	320	Male	12	23
			Female	7	9
Total			Male	51	138
			Female	38	102

bility of occurrence of such an event by chance is extremely small. A test of homogeneity (Table 2) indicates significant differences (0.01 level of probability) between the catches of nylon and linen gillnets in five out of seven days, and in the total catch. These data show that the catches from the two types of nets did not fit the expected value of equal catches, and that differences were homogeneous from day to day. Assuming that both fibers fished similarly, the results indicate that nylon caught over twice as many shad as did linen gillnets.

Comparisons of the length-frequencies of male and female American shad taken in nylon and linen anchor gillnets revealed a greater spread of total lengths for fish taken in nylon nets (Fig. 1 and 2). Differences in total lengths for the two types of nets decreased with increasing mesh sizes. Even though the extreme total lengths of fish from both net fibers were quite different, the modes were similar for the same mesh sizes. The tendency for larger fish to be taken in nylon nets can be explained on the basis of the greater elasticity of nylon fibers than natural fibers Miyamoto (1956:267–9). The catch of smaller size fish in nylon nets than in linen nets is more difficult to relate to the structural characteristics of the two fibers. Starr (1957:90) states that the smooth hard fiber makes nylon nets 50 to 100 percent more efficient than those of cotton and linen. It is possible that in addition to the reduced visibility of the hard smooth fiber, the latter characteristic may cause the fiber to hold smaller fish than fish caught in linen nets.

The regression of the logarithm of weight

TABLE 2.—Test of homogeneity of the American shad catches in nylon and linen anchor gillnets. Assumption expected catch equal (1:1).

Total Number Fish	Number Caught		"Chi Square" Values
	Nylon	Linen	
23	18	5	7.34
21	15	6	3.86
64	49	15	18.06
77	58	19	19.75
48	35	13	10.08
81	56	25	11.86
13	8	5	0.70
Total			71.65
Pooled 327	239	88	69.72
Interaction			1.93

Tabular "Chi Square" at 0.01 level
D.f. 7 = 18.475
6 = 16.812
1 = 6.635

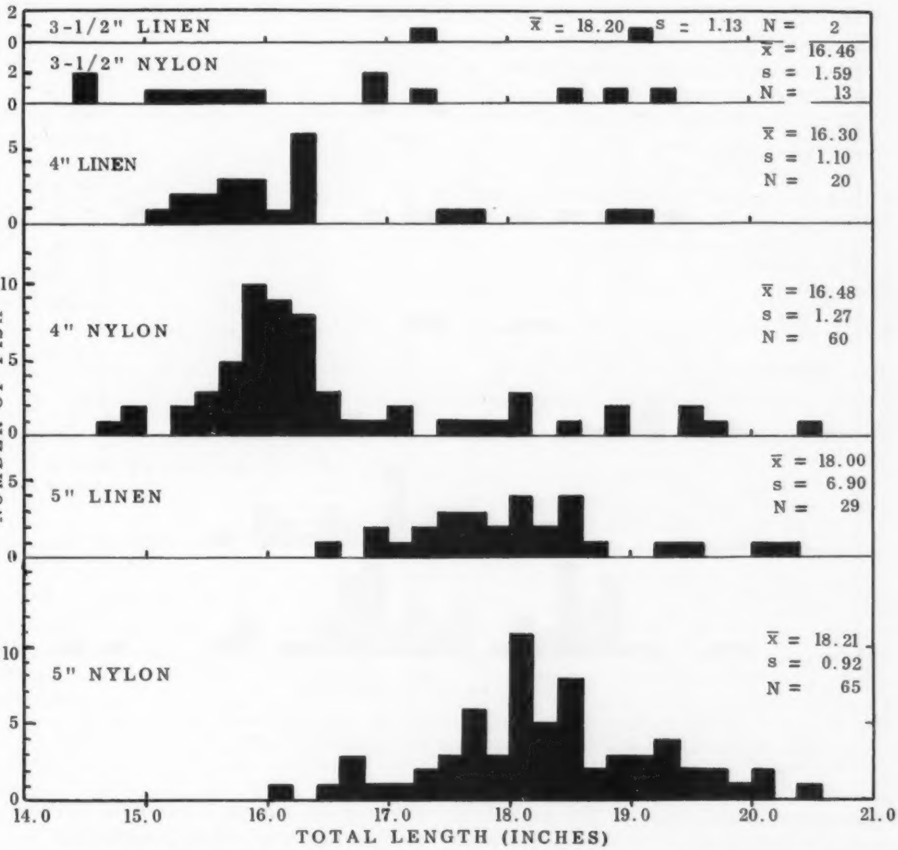

Fig. 1.—Length frequency distribution by 0.2 inch groups of male American shad, *Alosa sapidissima*, caught in 3½, 4, and 5 inch stretch mesh anchor gillnets of different fibers ($\bar{x}$ = mean, s = standard deviation, and N = number of fish).

on total length for male American shad from nylon was Log Y = 2.1868 + 2.9591 Log X, with a correlation coefficient (r) equal to 0.88, and from linen anchor gillnet was Log $\hat{Y} = -0.0801 + 1.2747$ Log X, with a correlation coefficient (r) equal to 0.94. The unit change of weight with a unit change of total length of the fish was significantly different (0.01 level of probability) between the two nets and was greater for the nylon nets (calculated $t = 11.9704$, tabular $t_{.01}$ for 128 and 46 fish equals 2.609). Thus, male shad above 18 inches T. L. taken in nylon nets were heavier than males of the same lengths taken in linen gillnets. A possible explanation of the heavier fish in the nylon nets is based on the elasticity of nylon fibers retaining a plumper fish of the same length while a more slender fish could pass through the meshes. Kipling (1957:51–63) discussed rather fully the problems of gillnet selection on estimation of length-weight relationships.

Length-weight comparisons between female American shad caught in the nylon and linen gillnets were not conducted since fish were in various spawning conditions and eels had fed on the spawn of 78 of the 140 gravid fish taken in the nets. The degree of damage to the body cavity and roe varied

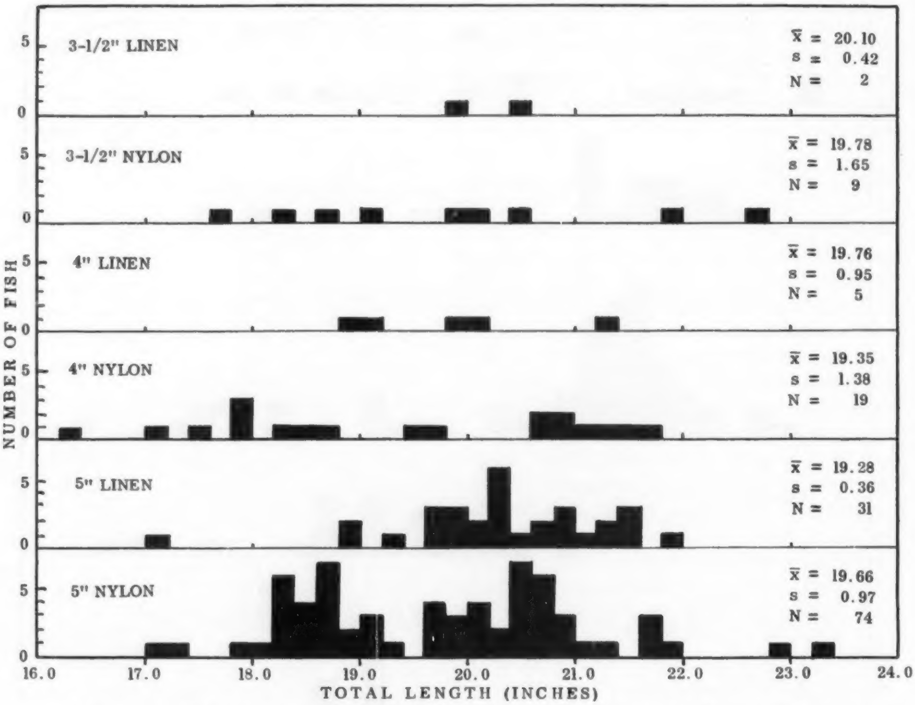

Fig. 2.—Length frequency distribution of female American shad, *Alosa sapidissima*, caught in 3½, 4, and 5 inch stretch mesh anchor gillnets of different fibers (see Fig. 1 for legend).

from only a small hole at the urogenital aperture to complete destruction of the body cavity.

The numbers of American shad caught in trials with nylon and linen drift gillnets were not large enough to permit detailed comparisons of the data (Table 3). Considering an expected catch in proportion to the number of yards of each fiber, which was one to two in favor of linen, a difference is not shown in the catch of the two fibers. In view of the small catches, these data do not justify any conclusions.

Table 3.—Comparisons of numbers of American shad gilled in 5½ inch stretch mesh nylon (137 yards) and linen (280 yards) drift net.

Date	No. Drifts	Number Shad		Expected (1:2)	
		Nylon	Linen	Nylon	Linen
May 8	1	3	0	1	2
May 20	1	2	5	2	5
	2	2	5	2	5
May 21	1	0	0	0	0
	2	0	0	0	0
Total		7	10	6	11

Herring: The catches of herring, both alewife and glut herring, were not as predominantly in favor of a larger catch being made in nylon as compared to linen nets (Table 4). If the probability was one-half that the catch in nylon nets would equal or exceed the catch in linen nets, such data had a probability of 0.38 of occurring. The small number of herring prevents statistical analysis of the data. Even though the herring catches are larger for nylon nets than for linen nets, conclusions based on such data have a large possibility of being in error. Herring were not taken in the larger mesh sizes. Comparisons of length-

TABLE 4.—Herring (alewife and glut) catches in matched sections of 3½ inch stretch mesh nylon and linen gillnets set overnight.

Date	Number Feet	Number Herring	
		Nylon	Linen
April 15	40	4	1
April 16	40	3	6
May 7	120	1	1
May 9	280	10	5
May 10	280	7	2
May 19	280	5	4
May 21	280	1	5
		31	24

frequency data of fish from the two fibers indicate only minor differences in total length distribution between the catches from the two fibers (Fig. 3).

Discussion and Conclusions

Analysis of the catches of American shad revealed considerable differences in the numbers, length-frequency and weights of fish from nylon and linen anchor gillnets. These comparisons were not possible with herring since only a small number of these fish were caught. American shad were not taken in sufficient numbers in drift gillnets to permit statistical analysis. Catches of American shad in nylon anchor gillnets were so different from the catches in linen anchor gillnets that the probabilities were small that such differences could have occurred by chance. This generally agrees with the observations of other investigators that nylon nets caught more fish than natural fiber nets Atton (1955:26), Lawler (1950:22–4), Molin (1951:59–65), Starr (1957:90), Ridenhour and DiCostanzo (1956: 700–4), and Peterson (1952:18).

In these previous studies cited above where several species of fish were taken in natural and synthetic fiber nets, the data were not always consistent with the same mesh size for all species. This phenomenon is probably related to the variations in optimum mesh sizes for species of fish with different body proportions and sizes. Atton (1955:21) attributed the lower ratio of ciscoes and whitefish in nylon and cotton nets of large mesh size to the decreased availability of large fish to these mesh sizes. This effect was demonstrated by the decreased length-frequency spread of Ameri-

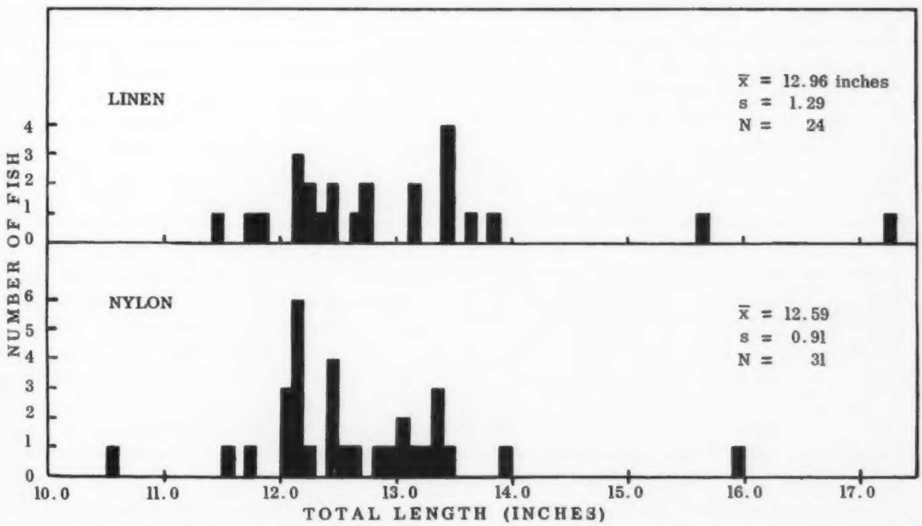

Fig. 3.—Combined length frequency distribution of alewives, *Alosa pseudoharengus*, and glut herrings, *Alosa aestivalis*, caught in 3½ inch stretch mesh anchor gillnets of different fibers (see Fig. 1 for legend).

can shad in the 5″ S.M. of different fibers as compared to the 3½″ and 4″ S.M. used in this study. This suggests that the structural features of the two fibers which cause the increased efficiency remain the same. The magnitude of differences in the catch decreases as the mesh size for a certain modal length exceeds the optimum number of shad available. The elasticity of nylon fiber results in the effective mesh sizes of nylon nets being greater than that of the same mesh sizes of natural fiber. If the mesh sizes of the different fiber nets were larger than the average size of the optimum number of fish which were available to the nets, then the differences in the catch between the different fibers should decrease with increased mesh sizes. Mesh sizes below the size at which the optimum catch in number of fish are made would result in increased catches in nylon nets as compared to natural fiber nets.

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Selection of Body Site for Scale Samples in the White Perch, *Roccus americanus*[1]

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ABSTRACT

Scales from 13 different areas of the body of white perch, *Roccus americanus*, were studied to ascertain the extent of variability in the calculated standard length at the formation of the first annulus. The objective was to determine the area from which scales most representative of all the areas could be sampled for age and growth studies. Calculated lengths from each area in 10 specimens ranging from 75 to 143 mm standard length from age groups I to III were compared with the average for all areas, and the one with the least deviation from the mean was considered suitable for age, growth and tagging studies. Minimum average differences were obtained from scales taken from the side of the body under the posterior two-thirds of the dorsal fins, both above and below the lateral line. Area 9 above the lateral line and between the spinous and soft dorsal fin was selected as the sample site in a study of the white perch population of the Patuxent River, Maryland.

Introduction

The problem of the proper body location from which to remove fish scales for age and growth analysis is recognized by many workers, and yet few clearcut criteria have been advanced to facilitate such a choice in critical studies. A number of workers have recognized that there is variation in scale size over the surface of the body which is great enough to be significant in scale studies. Standard fishery biological texts provide some hints on the body site from which scale samples may be taken, but except for some general comments by Everhart (1950:273) none give critical reasons for the choice. Rounsefell and Everhart (1953:325), for example, generally recommended that samples from fish with ctenoid scales be removed from the area immediately behind the pectoral fin. Lagler (1952: 108, 111) illustrated and suggested that scale samples from spiny-rayed fish be taken from the side of the body below the origin of the dorsal fin and just below the lateral line. Carlander (1950:13) suggested slight variations of the aforementioned citations.

Since age and growth studies for a single species are frequently compared between widely separated geographic regions, it is important that all the scales used in such studies originate from the same site. Back-calculations of the body lengths based on such an area would result in less error and give a more valid picture of the past life of the fish. It has long been recognized (Merriman, 1941:23; and Everhart, 1950: 272) that the shape and size of scales from different regions of the body vary to a marked extent. Thus, scale measurements can only be considered comparable if the samples are homologous. It is proposed that differences in the choice of site for scale samples can be obviated by an objective approach to the problem. Also, studies may reveal each species to have its own optimal site for scale samples. This project was begun to ascertain the extent of variability in the calculated standard length at the formation of the first annulus of scales taken from 13 different parts on the body of the white perch, *Roccus americanus* (Walbaum). This work preceded a larger study of the vital statistics of this species (Mansueti, 1957), and contributed directly to the selection of the optimal site for scale samples. The assumptions on which age determination is based, tested in another part of this study, and for innumerable other species, is considered valid for

[1] Contribution No. 148, Maryland Department of Research and Education, Solomons, Maryland.

the white perch. The relief features of scales from this species are so clearly evident as to permit their use in age and growth determinations, since annuli can be easily counted and measured.

Methods and Materials

Ten white perch for this study were collected from a single locality on a single date in August, 1950. They ranged in size from 75 to 143 mm in standard length and were examined for the presence of at least one annulus. Age analysis indicated that they were drawn from age groups I to III. Scales were taken from 13 different areas on each fish (Fig. 1), suggested by the work of Phillips (1948:99–106) and Miller (1955: 18–21), much like the aproach of Dannevig and Høst (1931) and Kaganovskaya (1937). These criteria were established for scales derived from the body site chosen for sampling: (a) estimates of length would be representative of scales from all sites; (b) they must be average in size, symmetrical and easy to read; and (c) their removal must not injure or hamper normal swimming of fish. This approach and the criteria cited above differed from Perlmutter and Clarke (1949:208) who divided the side of the rosefish. *Sebastes marinus*, into 16 areas. They sought the largest and most uniformly shaped scales with the highest circulus count, since the latter would indicate the maximum growth from the beginning of scale formation. It differed from the study by Harmic (1952:37) who did not determine an overall mean of scale radius lengths for computing the deviations of his arbitrary body divisions in the bluegill, *Lepomis macrochirus*. His effort was restricted to assessing the relative variability of scale radii within various areas, and he chose the least variable, whether it reflected average growth conditions of other scale areas in the specimen or not. Since average growth, rather than maximum growth or scale areas with minimum variability, was desired, circulus counts or detailed tests of within area variation were not made in the white perch study.

To define the areas in the white perch, three horizontal regions were set apart by lines drawn anteriorly from the dorsal and ventral edges of the hypural region of the

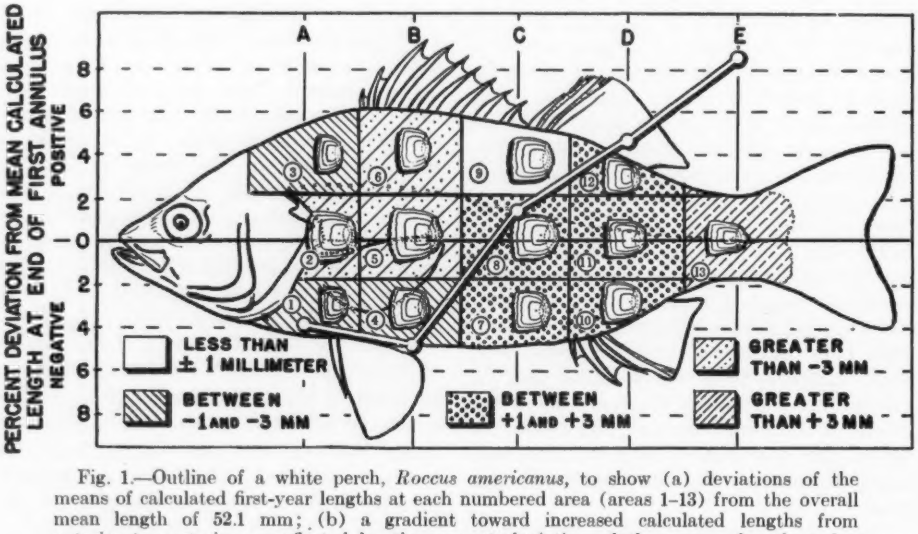

Fig. 1.—Outline of a white perch, *Roccus americanus*, to show (a) deviations of the means of calculated first-year lengths at each numbered area (areas 1–13) from the overall mean length of 52.1 mm; (b) a gradient toward increased calculated lengths from anterior to posterior as reflected by the percent deviation of the mean of each region (A = areas 1–3; B = 4–6 . . . E = 13) from the overall mean of 52.1 mm; and (c) the consistent variation in sizes and shapes of scales from different areas, based on 130 scale samples from 10 different fish.

tail. Five vertical lines were arbitrarily drawn on a hypothetical fish body to set apart the five body regions as follows: (1) anteriorly, the first vertical line was drawn from where the ventra-thoracic region disappears beneath the opercular flaps; (2) the second vertical line was projected down from the origin of the first dorsal spine; (3) the third vertical line was extended up midway between the origin of the pelvic fin spine and the first anal spine; (4) the fourth vertical line was projected up from the origin of the first anal spine; and (5) the fifth vertical line was projected down from the point of the greatest extension, horizontally, of the last ray of the soft dorsal fin. About 10 scales were selected at the center of each area. An effort was made initially not to select scales for clearness or ease of age determination. This was done to calculate the approximate variation that could be expected in routine age analyses.

The impressions of selected scales were made on cellulose acetate, and the images were magnified to 30 diameters by means of a Rayoscope projector. For the comparison of calculated standard lengths, four scales from each area were measured along the midlongitudinal axis from the base of the sculptured area or focus to the first annulus and to the margin. Among scales that were not bilaterally symmetrical, an equal number of long and short shoulders were measured from each fish. Also, diagonal measurements from the focus to one anterior shoulder of each scale were made for comparative purposes. In addition, the greatest length and breadth of each scale were measured. Fig. 1 also shows the range of sizes and shapes of scales from the 13 areas as reflected by a detailed study of scales from three different sized white perch. A straight line relationship of scale length to body length with a graphical intercept at 0 was assumed. Thus, the fish length to the first annulus was calculated from the following relationship:

$$\frac{\text{Length of scale included in annulus of year X}}{\text{Total length of scale}} = \frac{\text{Length of fish at end of year X}}{\text{Length of fish at time of capture}}$$

TABLE 1.—Comparison of two methods of computing average calculated lengths in mm at the first annulus on scales from 13 different areas on the side of 10 white perch, *Roccus americanus*, ranging from 75–143 mm standard length.

Scale Area	Mid-anterior Mean	Vertical Margin Average Difference	Latero-anterior Mean	Diagonal Margin Average Difference	Differences Between Vertical and Diagonal Measurements	
					Value	Percent
1	50.0	−1.9	50.8	−1.3	0.8	0.098
2	48.3	−3.6	49.0	−3.1	0.7	0.098
3	49.5	−2.4	50.3	−1.8	0.8	0.098
4	49.7	−2.2	51.0	−1.1	1.3	0.097
5	48.8	−3.1	49.1	−3.0	0.3	0.099
6	48.1	−3.8	48.8	−3.3	0.7	0.098
7	53.5	+1.6	53.7	+1.6	0.2	0.099
8	52.8	+0.9	53.1	+1.0	0.3	0.099
9	51.9	0.0	52.0	−0.1	0.1	0.099
10	55.3	+3.4	55.0	+2.9	0.3	1.005
11	55.3	+3.4	54.9	+2.8	0.4	1.007
12	54.2	+2.3	53.6	+1.5	0.6	1.011
13	57.1	−5.2	56.6	+4.5	0.5	1.008
Grand Mean	51.9	—	52.1	—	—	—

Results and Discussion

Lengths of Fish Calculated to the First Annulus

Mean calculated lengths were quite variable for certain areas (Table 1). This is reflected by both diagonal and mid-logitudinal measurements which differed very little from one another. For the averages of the series of 10 fish, the greatest difference between the calculated lengths was found in scales taken from area 13, 2, 5, and 6, i.e., the caudal peduncle and the region between the spinuous dorsal fin and the origin of the pectoral fin. Area 13 yielded fish lengths that were at least 4.5 mm greater than the average for all areas combined. In contrast, Harmic (1952:37) found scales within the caudal peduncle region to be the least variable within that area when compared to variability within other areas. His comparisons were not derived from an overall mean as in this study, hence the striking difference. Everhart (1950:275) found that caudal peduncle scales of the smallmouth bass, *Micropterus dolomieu*, gave growth

estimates that differed markedly from pectoral scale estimates. Area 6 in the white perch also yielded lengths that were at least 3.3 mm less, a total difference of 7.8 mm. The marked deviations from the average for all areas combined were relatively consistent for both diagonal and mid-logitudinal measurements of each scale, although there was a tendency for the former to be slightly greater than measurements from the latter. The differences were not statistically significant.

In general, scales that yielded the greatest calculated lengths to the first annuli were found in the areas that formed the posterior region of the body, i.e., areas 10, 11, 12, and 13; scales that yielded the least calculated lengths to the first annuli were in areas that formed the antero-dorsal region of the body, i.e., areas 2, 5, and 6. Thus, there was a gradient toward increased lengths from the anterior region of the body toward the tail in the white perch. Fig. 1 also shows the percent deviation of this phenomenon for the average of body regions, A = 1–3, B = 4–6, C = 7–9, D = 10–12, and E = 13, from the overall mean of 52.1 for all 10 white perch. This is in agreement with the observations of Dannevig and Høst (1931:67) and all of the studies they cited for a wide variety of salmonoid and gadoid fishes, a herring and a flounder. It suggests that growth is not quite simultaneous in the different parts of the body, and that all scales do not grow in direct proportion to the total length. Whether the scales from a particular area grow in close correspondence with the part of the white perch body in question is difficult to determine at this time.

The zone in which minimum average differences of calculated lengths were found extended from beneath the posterior two-thirds of the two dorsal fins to the area between the posterior soft dorsal fin and the anal fin. Area 9 was remarkably and consistently close to the overall average in the calculated lengths for the first annulus. Area 8 followed by 7 and 12 also showed minimum average differences. Although Perlmutter and Clarke (1949:208) used a somewhat different method of scale sample selection from 16 areas on the body of the rosefish, they found that the most suitable scales came from the "pectoral patch," behind the pectoral fin between the dorsal and ventral areas on the center of the body. The latter was somewhat below area 9 and approximately over area 8 in the white perch. This region may be unsuitable as a sample site for salmonoid fishes, for Dannevig and Høst (1931:80) found that identification of first year growth may be impossible in the pectoral region of the Atlantic salmon, *Salmo salar*, and brown trout, *Salmo trutta*, hence they did not recommend the area for a scale sample. Significantly enough, area 9 of the white perch body in both diagonal and mid-logitudinal measurements showed virtually no differences, respectively, from the average for all areas combined.

Other studies show similar results to those reported herein, even for widely different groups of fishes. Kaganovskaya (1937:123–4), in working with the sardine, *Sardinops melanosticta*, in Russian waters, divided the body into seven sections for a somewhat similar study of the scales. He concluded that the most authentic data concerning the growth of the sardine can be obtained from scales taken from before and under the dorsal fin below the middle line of the body. Phillips (1948:99), after dividing the body of the Pacific sardine, *Sardinops caerulea*, into 13 areas, found that the minimum average differences in calculated lengths are obtained from scales taken in a zone extending from the pectoral fin upward and backward on a diagonal to the lateral line area and ending midway between the anterior insertions of the pelvic and anal fins, somewhat similar to Kaganovskaya. Miller (1955:19) also divided the body of the northern anchovy, *Engraulis mordax*, into 13 areas, and found that the zone of minimum average differences extended from the pectoral region, backward and upward to the anterior region of the caudal peduncle. Merriman (1941:23) and Tiller (1950:3), who investigated the problem of scale sample site on the striped bass, *Roccus saxatilis*, a close relative of the white perch, did not divide the entire body into arbitrary areas as some other workers. Rather, their studies were apparently re-

stricted to a small, subjectively-chosen part of the mid-body region. Hence their conclusions, while generally similar to the results of the white perch analysis, must be further tested by critical studies of the entire fish's body. The results of the scale selection site study by Harmic (1952:37–9), in which he recommends the caudal region, diverges from all of these statistical studies and intuitive recommendations by workers cited in the introduction. Everhart (1950: 272) compared growth estimates from the pectoral and caudal scales and suggested that the estimates from the latter were not efficient. Thus, it seems that the atypical size and shape of caudal peduncle scales and the relatively inaccurate estimate of previous growth from the area points to the use of scales from more anterior regions of the fish's body.

Greatest Lengths and Breadths of Scales from Various Body Areas

Data summarized in Table 2 furnished information about the maximum dimensions of scales and permitted comparisons between these and the usual scale measurements from the base of the sculptured areas to the margin. Fig. 1 shows how the shape and sizes of scales from the different sites varied, probably to conform with the curvature of the body and placement of fins and gillslits. Scales of the greatest average length occurred in area 5, followed by area 2. Seven of the areas were represented by sizes that were below the overall average length of all the areas combined. Scales of the smallest average lengths occurred in areas 1, 3, and 12, respectively. In general, scales having the greatest average length occurred in the zone between the origin of the pectoral fin and the lateral line backward to the caudal peduncle. This corresponded to the zone of maximum deviations (2, 5 and 13) and the zone of medium deviations (8 and 11).

Scales of the greatest average width, as with the greatest lengths, occurred in areas 2 and 5. They were also outstandingly broad in areas 4, 6 and 8. Seven of the areas were represented by scale sizes that were below the overall average width of all the areas combined; those with the smallest average

Table 2.—Average sizes in mm (30×) of scales for the corresponding areas of the 10 different-sized white perch, *Roccus americanus*.

Area of Scale Selection	Greatest Length of Scale	Greatest Width of Scale	Length and Width Combined (÷2)	Mid-longitudinal Length of Scale from Focus to Margin
1	70.1	83.1	76.6	47.3
2	100.2	109.7	105.0	65.9
3	72.2	87.4	79.8	46.4
4	88.2	98.4	93.3	61.3
5	107.6	110.8	109.2	74.7
6	84.5	96.8	90.7	56.5
7	85.8	95.2	90.5	58.7
8	95.8	96.5	96.2	67.2
9	84.6	90.8	87.7	57.3
10	87.2	89.5	88.4	61.5
11	88.2	86.3	87.3	61.3
12	83.4	87.0	85.2	56.8
13	88.6	77.7	83.2	60.7
Average	87.4	93.0	90.2	59.7

widths occurred in 13, 1, 11, 12 and 3, respectively. A combination of the length and width measurements gave a value that is more in keeping with the actual magnitude of the scale. Thus, scales of the largest size are to be found in the adjacent areas 5, 2 and 8 which are in the anterior central portion of the body largely below the lateral line.

Comparison of Greatest Sizes of Scales with the Usual Scale Measurement from the Focus to Margin

In comparing the greatest dimensions of scales with the distance of focus to margin, or radius, all three measurements were found to be statistically correlated (Table 3). In each of the foregoing comparisons, the probability was less than one in a hundred of arriving at such high values by chance alone, if there were no correlation. The results of these tests indicated that the measurements from the focus to the margin of the white perch scale along the mid-longitudinal axis was more closely associated with the greatest length of the scale than with the greatest width, as Phillips (1948:104) found with *Sardinops caerulea*. In fact, the correlation between the greatest lengths and focus-to-margin measurements was even better than that between the

TABLE 3.—Coefficients of correlation of various measurements of scales from white perch, *Roccus americanus*, with the distance of focus to margin in the same scales, and the statistical significance of correlation.

Focus to Margin Distance Related to	Coefficient of Correlation	t-values at 1% level (12 d.f.) = 3.055	Table of Correlation Coefficients value at 12 d.f.	Significance
Greatest Length of Scale	+0.982	17.9	0.661	High degree of correlation
Greatest Width of Scale	+0.661	9.66	0.661	Correlation statistically significant
Greatest Length and Greatest Width of Scale Combined	+0.903	23.01	0.661	High degree of correlation

focus-to-margin and the greatest lengths and widths combined. This was contrary to Phillips' (op. cit.) findings, i.e., that the best association existed between the combined greatest lengths and widths and the focus-to-margin measurement. The qualitative differences between the scales of spiny-rayed versus soft-rayed fish probably account for these observations.

THE SELECTION OF THE DIAGONAL VERSUS MID-LONGITUDINAL MEASUREMENTS

Early in the study several different methods of measuring the distances between the focus and annuli were considered. Three possibilities were apparent: (1) a measurement from the focus to the mid-longitudinal margin, which has been presented in preceding computations; (2) a measurement diagonally from the focus to the anterior shoulders of the scales; and (3) a measurement transversely from the focus to the lateral edges of the scale. The last method was not used because it was apparent that errors in the placement of the measurements were very great.

The choice between the diagonal and mid-longitudinal measurements was based on the quantitative approach summarized in Table 1. Comparisons between the two types of measurements of all areas for the 10 fish show that there were minor differences, the diagonal having slightly higher values. A t-test conducted to show the significance of differences between the two overall means of the means of the combined 13 areas, however, showed them to be not statistically different (t-value = 0.0175 at 24 d.f., at 5 percent = 0.685). Everhart (1950:274) found statistically non-significant differences in the two types of measurement in the smallmouth bass. The differences between the two types of measurements in area 9 in the white perch were also negligible. Since this area represented the section of least deviation (Fig. 1), the non-significant difference contributed importantly in the final decision of the choice of sample site.

Summary and Conclusions

Scales taken from near the midline of the back, from just behind the head directly under the spinous dorsal, from near the mid-ventral portion of the body, and from near the base of the tail did not seem to be fully satisfactory when the calculated lengths were compared with one another. These approximate areas 2, 5, 6, 8 and 13 of Fig. 1, and as can be seen on Table 1, all of these, with the exception of area 8, deviated markedly from the average calculated length. In addition, some scales from these areas were misshapen, or the annular markings were marred or interrupted by excessive scarring, thereby causing some uncertainty in the identification of annuli. On the other hand, practically all other scales in the posterior-mid section of the body were satisfactory provided they were not regenerated.

The final decision on the choice of the area from which scales were taken rested on the following requirements: (1) the area would represent the region of least differences from average calculated lengths; (2) the scales would be symmetrical, close to the average size for scales from all areas, and free of distortions and a high prevalence of regeneration; and (3) scale removal

would not hamper the swimming ability. Area 9 fulfilled these requirements remarkably well. Since this area was located above the lateral line and largely above the line of the vertebral column, it proved useful in tagging studies. Thus, for the purpose of attaching a Petersen disk tag by inserting a pin into this area after removing a scale sample, this area was of double importance.

The results indicate that minimum average differences in calculated lengths were obtained from scales taken in the mid-posterior section under the posterior two-thirds of the length of the dorsal fins, both above and below the lateral line. Area 9 above the latter was included in this section of the body, and because it fulfilled the requirements listed above was chosen as the area for scale samples during age, growth and tagging studies.

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Notes and Comments

A Megalops of the Blue Crab, *Callinectes sapidus*, in the Patuxent River, Maryland[1]

ABSTRACT

A megalops of the blue crab is recorded in the Maryland part of Chesapeake Bay for the first time. Salinity was 17.1 ‰ and temperature 17°C on October 14, 1957. This record extends the northward intrusion of this form in the bay about 65 nautical miles.

On October 14, 1957, a single megalops of the blue crab, *Callinectes sapidus* Rathbun, was secured from a four-square foot bottom sample off Sandy Point, 1.5 nautical miles west of the mouth of the Patuxent River near Solomons, Maryland. This record is the first such occurrence in which this stage has definitely been found in the Maryland part of the bay. The salinity at the time of sampling was 17.1 ‰ and the temperature was 17°C. During the 45 days previous to the sampling, the surface salinity at a tide station about 300 yards to the north averaged about 2.0 ‰ above the 20-year moving average for the same location. The water depth at the sampling site was about one foot at low tide.

The megalops of the blue crab has been described from the Virginia part of Chesapeake Bay by Brooks (1882), Robertson (1938), and Churchill (1942). Hopkins (1943, 1944) and Sandoz and Hopkins (1944) have described the zoeae of this species. Goellner (1941) reports obtaining megalops at six stations, all near the Cape Charles-Cape Henry area in Virginia. Van Engel, in a personal communication (April 8, 1958), reports that he has collected these forms at Virginia Beach and Cape Henry and has some recollection of a megalops having been collected in the York River at Gloucester Point, Virginia. Beaven (1932) gives an account of large numbers of megalops occurring at Virginia Beach, Virginia, in August 1931. The occurrence reported herein, extends the northward intrusion of this form in the Chesapeake Bay about 65 nautical miles.

The specimen has been examined by Dr. Fenner A. Chase, Curator, Division of Marine Invertebrates, U. S. National Museum, and by Dr. Sewell H. Hopkins of the Agricultural and Mechanical College of Texas. They both concur with the author that the larva is *Callinectes sapidus* or a closely allied species. No other members of this genus are known to frequent the Chesapeake Bay. No attempt will be made to explain its intrusion into less saline waters since very little is known of its ecological requirements.

Grateful appreciation is expressed to Dr. Chase and Dr. Hopkins for verifying my identification, and to Mrs. Carol B. Whitesell of this laboratory for bringing the specimen to my attention.

[1] Contribution No. 149, Maryland Department of Research and Education, Solomons, Maryland.

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An Unusually Large Pugheaded Striped Bass, *Roccus saxatilis*, from Chesapeake Bay, Maryland[1]

ABSTRACT

A deformed striped bass with typical pugheaded features, weighing 5¼ pounds and measuring 19.3 inches fork length, is described and compared with a normal specimen. A six-year-old male, it apparently exceeds all previous size records for pugheaded striped bass. The specimen possesses an acutely steep forehead and pushed-in snout, exophthalmic eyes, enlarged and broadened mandible, and incomplete closure of jaws. It was in good condition, although size attained at each age was less than that for normal striped bass at the same age. The literature is reviewed in some detail and factors that induce pugheadedness, believed due to environment and heredity, and not mechanical injury, are discussed briefly.

The capture of a pugheaded, or pugnosed, striped bass, *Roccus saxatilis*, weighing 5¼ pounds and measuring 19.3 inches fork length, apparently represents for Chesapeake Bay a new size record in the species with this abnormality. It was caught in early May, 1960 by an angler in about 60 feet of slightly brackish water near Miller Island off the mouth of Middle River, an upper Chesapeake Bay tributary near Baltimore. It was taken with five other striped bass that ranged up to 12 pounds in weight and a 17-inch largemouth bass, *Micropterus s. salmoides*. The latter, taken in shallower water nearby, indicates a low-salinity habitat.

The specimen, a male, is a typical example (Fig. 1) of the pugheaded anomaly first described and illustrated in detail for the striped bass by Sutton (1913:195-9) and Gudger (1930:1-11). It had these important abnormal features: (a) a strikingly shortened and broadened maxilla, the bones of which extended across the buccal cavity; (b) an acutely steep forehead and pushed-in snout; (c) exophthalmic eyes; (d) a scarred, enlarged and broadened mandible with a pigmented tongue; (e) incomplete closure of the mouth with downward hanging outer ends of both jaws; and (f) generally heavy body in the anterior region. All of these features have been observed and described by Gudger and Sutton, both of whom also described pertinent osteological modifications in the skull caused by the deformity. Sutton found that the exposed tongue was pigmented, a feature cited above and also observed by Gudger, and claimed that it was covered with rudimentary scales. None of the latter were found in the specimen described herein, nor those studied by Gudger (1930:10).

In spite of this deformity, the fish was relatively plump (Fig. 2) and apparently able to feed normally since its stomach contained a large amount of unidentified, well-digested remains, partly fish. The coelomic cavity also contained much fat. The testes were enlarged. This specimen has been compared to a normal but slightly smaller female in weight (Table 1). It was assumed that there was no difference in morphometric features between the sexes, as indicated by Lund (1957:3) in a more detailed study. The heavier weight in the male taken in May was due to enlarged ripe testes, while the female taken in August contained much smaller immature ovaries (14 × 78 mm). Vladykov and Wallace (1952:156-7), for example, showed for the 15-inch size class that females in August were 28 percent lighter (versus 10 percent in Table 1) than males in February when the gonads are almost as well-developed as in May. Thus, the two specimens are considered comparable for morphometric and growth aspects.

Examination of the scales of the pugheaded fish indicated that it was a member of age group VI (1954 year class). Back calculations of sizes at previous ages indicated the following approximate fork lengths: size at age I—5.5 inches; II—8.2; III—10.8; IV—13.2; V—15.6; and VI—17.9. The normal specimen was from age group IV (1956 year class) with these calculated fork lengths: size at age I—5.4 inches; II—12.7; III—16.7; and IV—19.8. The sizes of the pugheaded fish were compared with extensive unpublished data on the average growth of males at different ages, and were found to be smaller at each comparable age group, markedly so beyond two years of age. The sizes of the normal fish compared favorably with the average growth for females, and that of the sexes combined, and the differences were insignificant. These comparisons suggest that the deformity prevented the fish from attaining optimum growth experienced by normal fish. Important differences between head measurements in normal and pugheaded fish are also given in Table 1.

Pugheadedness in striped bass is not an unusual deformity, although published references are relatively few. They apparently indicate that none of the fish exceeded the weight of 3 pounds. Gudger (1930:9-11) searched out the early literature and provided a critical review of the observations. Ayres (1849:121) did not give the weight and size of his pugheaded striped bass. Sutton (1913:195-9), who presented an excellent morphological description of a pugnosed striped bass, did not give the length of his fish, but it weighed 2.75 pounds. Gudger (1930:9) reported that the *New York Sun* for December 21, 1919 published a figure of a pugheaded striped bass that weighed 2½ pounds. Of the three specimens he studied, he gave measurements for two: 16.8 and 16.5 inches, respectively. These could have weighed up to 3 pounds each. The third specimen was about this size, judging

[1] Contribution No. 150, Maryland Department of Research and Education, Solomons, Maryland.

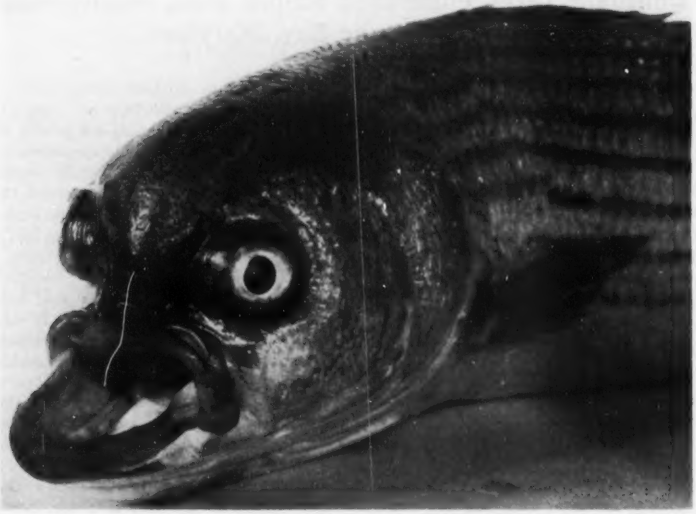

Fig. 1.—Pugheaded deformity in the striped bass, *Roccus saxatilis*, that weighed 5¼ pounds and measured 19.3 inches fork length. Photograph courtesy of Mr. Bill Burton, The Baltimore Sun Papers.

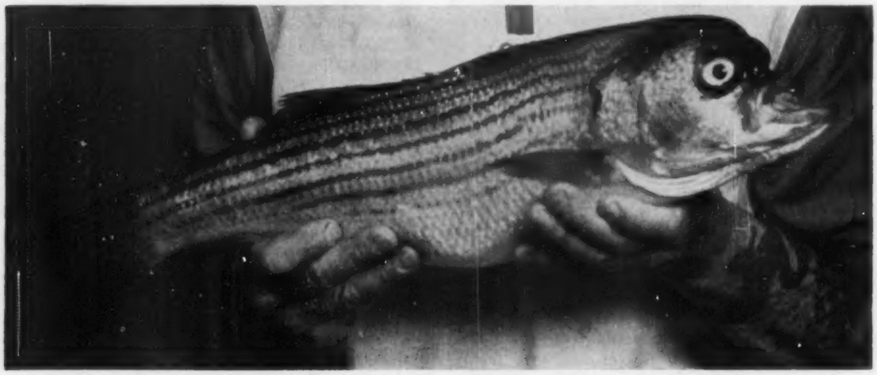

Fig. 2.—Body shape of a freshly caught pugheaded striped bass, *Roccus saxatilis*, showing plump body and normal features of the outline. Photograph courtesy of Mr. Bill Burton, The Baltimore Sun Papers.

from other measurements given on p. 3. Covell (1957:C-4) showed a photograph of a pugheaded striped bass and stated that the fish was 17 inches long. Unfortunately, the size of the specimen cited by the Crisfield Times (1960:10) is not given.

Actually, the deformity is present in specimens at a fairly wide range of sizes. Two fingerling pugheaded striped bass (one 52.9 mm F.L.) were seined among several hundred specimens from Oldfield Point, Elk River, Cecil Co., Md. on October 5, 1960. There is evidence of the capture of even larger pugheaded striped bass than herein reported. Mr. Robert Pond, a fishing lure manufacturer from South Attleboro, Mass., reported that a fish, 24" (F.L.), weighing roughly six pounds, was caught in Massachusetts waters and is mounted in the Fall River Line-siders Club, Mass. Mansueti (1958: 30–2) cited two specimens, each less than one pound in weight and about 12 inches long taken in Chesapeake Bay. He also described and illustrated postlarval and recently transformed young with a typical pugheaded abnormality. Methods of feeding by these young were also described as well as the factors that induce pugheadedness in striped

TABLE 1.—Comparison of measurements in millimeters of the head of a pugheaded with a normal striped bass, *Roccus saxatilis*.[1]

Body character	Pugheaded specimen	Normal specimen	Percent deviation of pugheaded from normal fish
Fork length	490	579	−15
Weight (oz)	84	72	+10
Head length	129	152	−15
Head depth	102	90	+12
Head width	90	68	+24
Postorbital head length	86	89	−0.04
Snout length	20	48	−58
Interorbital width	35	42	−17
Orbital width	23	19	+8
Orbital length	25	19	+24
Maxillary length	43	61	−30
Width of gape	49	66	−26
Age group	VI	IV	—
Sex	Male	Female	—

[1] Methods of measurement follow Hubbs and Lagler (1958:24–6).

bass. He suggested that the specimen illustrated as a "hybrid between the shad and rock-fish" by Ryder (1887:503, 548) was a pugheaded postlarval striped bass. Burton (1960:33) first called attention to and illustrated the specimen described herein.

Judging from the size of the 5¼ pound specimen, and those discussed above, it is clear that the pugheadedness is not a hinderance to survival and growth in striped bass. Although Gudger (1930:18–9) indicated that the feeding process in such specimens was unknown, Mansueti (1958:30–1) described the feeding behavior of pugheaded young and remarked that they feed almost as efficiently as normal young striped bass. As suggested above, however, the deformity may affect growth most markedly at sizes exceeding 12 inches. The factors that induce this anomaly in various species were reviewed by Mansueti (1958:31–2). Mechanical injury has been discounted as a primary factor. Of several authors who have cited this abnormality in various species of fishes, Schaeperclaus (1954:618–20) presents the best review of the principal factors involved. The best evidence indicates that pugheadedness can arise in a variety of teleost families, and that it may result from a germinal defect in the embryo. Its course may be directed by adverse conditions, especially an oxygen deficiency in the micro-environment of the early developmental stages. Mansueti (1958:32) noted that pugheaded and normal fish were found among siblings hatched from phenotypically normal striped bass parents. This finding suggests that both environmental and genetic factors may be involved and that the degree of each can only be determined by an experimental approach.

Grateful appreciation is expressed to Mr. Bill Burton, outdoor editor of the Baltimore Sunpapers, for donating the specimen, and loaning the photographs for reproduction.

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Notes on the Nudibranch, *Elysia chlorotica*, from Chesapeake Bay, Maryland[1]

ABSTRACT

Nudibranchs, *Elysia chlorotica* Gould, ranging from 5 mm to 28 mm in length, were identified for the first time at two locations in the Chesapeake Bay. This is a southward extension of its reported former range which was Massachusetts to New Jersey. A brief discussion of ecological data and activity associated with the organisms is presented.

The nudibranch *Elysia chlorotica* Gould was reported by Johnson (1934:153) to occur from Cambridge, Massachusetts, to Great Egg Harbor, New Jersey. Several specimens have been collected recently at two locations within the Chesapeake Bay; namely, the mouth of the Patuxent River, and Eastern Bay, Maryland. This is believed to be the first record of this species south of its originally outlined range. Identification has been confirmed by Dr. Harald A. Rehder, Curator of Mollusks, United States National Museum. The specimens agreed closely with the description given by Gould (1870:255) with the exception that individual coloration varied considerably. The smaller, presumably immature specimens, were dark grey-green in color while the larger specimens were emerald green, agreeing more with the original description. The body and head surfaces of all specimens were mottled with an irregular pattern of white interspersed with minute red spots.

On February 16, 1960, a specimen 28 mm long and 4 mm wide (17 mm wide when lateral folds were expanded) was taken in a benthic sample along with other invertebrates from sand flats of the Patuxent River in front of the Chesapeake Biological Laboratory, Solomons, Maryland. The sample was taken in a dense growth of eelgrass, *Zostera marina*, which was covered by about two feet of water at low tide. Water temperature was 4.3° C and the salinity was 13.3 ‰.

Two other specimens were found in another sample taken on March 28, 1960, from the same area except that the predominant vegetation consisted of unidentified algae instead of eelgrass. They were considerably smaller than the first individual, measuring 11 and 6 mm in length by 6 and 5 mm in width, respectively. The water temperature at this time was 6.4° C and the salinity was 13.2 ‰.

Since the first two collections, several other specimens were taken during the first part of April ranging from 5 mm to 11 mm in length. Although the methods of collecting were continued in this area, no nudibranchs were found after the middle of April.

Two months later, however, on June 15, 1960, a comparatively large specimen was found in the Eastern Bay region of the Chesapeake Bay. This collection, made in Crab Alley Creek, is a considerable distance from the first area of collection in the Patuxent River. The single specimen was found on the shell of a live oyster which was dredged from a natural oyster bar in approximately 10 feet of water. Vegetation throughout the area was very dense, consisting primarily of eelgrass and clasping-leaf pondweed *Potamogeton perfoliatus*. The recorded water temperature at this location was 23.7° C with a salinity of 10.5 ‰.

In Massachusetts, Russell (1946:96) reported an abundance of immature *Elysia* between 6 and 19 mm in length during May in salt marsh pools on Pasque Islands, southwest of Woods Hole. The temperature in these shallow pools varied from 12.2° C at night to 21.7° C during the day with a salinity of 32 0/00. A comparison of these values with the data obtained in Maryland shows that within its coastal range, *Elysia* is capable of withstanding wide ranges as well as a rapid change in temperature. Likewise, a tolerance for salinities associated with either marine or estuarine environments is evident.

Some of the nudibranchs were held in an aquarium for several months, and yielded observations of almost predictable periods of activity and rest during the daylight hours. Movement was always a slow, continuous flow over the bottom and vertical surfaces of the aquarium. At no time was *Elysia* observed using the broad lateral folds or ridges as a means of movement or gliding through the water as has been reported by Crowder (1931:359) and Miner (1950:674). For short periods during the morning hours, presumably before

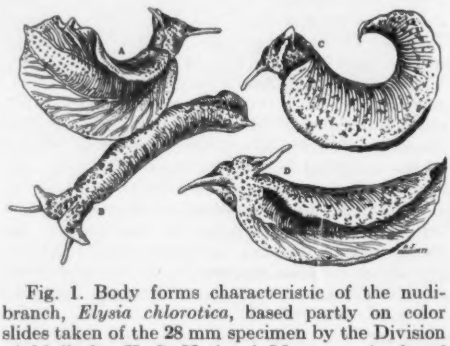

Fig. 1. Body forms characteristic of the nudibranch, *Elysia chlorotica*, based partly on color slides taken of the 28 mm specimen by the Division of Mollusks, U. S. National Museum: A. dorsal view with lateral folds almost fully expanded; B. ventral view showing lateral folds completely closed; C. dorsolateral view; and D. dorsal view with lateral folds half-opened.

[1] Contribution No. 151, Maryland Department of Research and Education, Solomons, Maryland.

the intensity of sunlight became too great, the broad, lateral expansions were unfolded, displaying maximum body surface area. This position could be maintained while moving or at rest (Fig. 1).

Since only a few specimens have been observed at two widely separated areas, it is not possible to determine the extent of distribution or population density in the Chesapeake Bay. With the limited data available, one could only speculate on the factors contributing to its present appearance in a locality where the invertebrate fauna has been sampled frequently in the past.

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Sounds Produced by Very Young Crevalle Jack, *Caranx hippos*, from the Maryland Seaside[1]

ABSTRACT

Three very young crevalle jack, ranging from 38 to 41 mm total length, emitted a burst of rapid, short, rasping croaks upon being landed in a beach seine out of the ocean surf. Dissection revealed well-developed upper and lower pharyngeal teeth indicating that sounds were produced as in the adults.

Adult crevalle jack, *Caranx hippos* (Linnaeus), are known to produce a continuous harsh croak by scraping the upper and lower pharyngeal teeth patches together (Bridge, 1904:335, in Harmer, *et al*, 1904; Burkenroad, 1931:21–2; and Fish, 1954:30). The sounds of other species of carangid fishes, including *Trachinotus palometa* [= *T. glaucus*] and *T. carolinus* (Dobrin and Loomis, 1943: 10), *Seriola zonata*, and *Caranx crysos* (Fish, Kelsey and Mowbray, 1952:188), and *Alectis cilaris* [= *A. crinitis*] (Fish, 1954:30–1) have also been characterized. Earlier, Fish (1948) recorded croaking and grunting from *Vomer setapinnis, Chloroscombrus chrysurus, Selene vomer, Caranx latus* and *Trachinotus glaucus*. In none of these references has any mention been made of audible sounds produced by young-of-the-year carangids. Although Fish (1954:31) found that fingerling blue runners, *Caranx crysos*, ranging from 150 to 195 mm long in a school, produced a large amount of sound, these sizes are considerably larger than the specimens described herein.

Three very young specimens of *Caranx hippos*, 38, 39 and 41 mm in total length, were seined in the Atlantic Ocean surf off Assateague Island, Maryland on August 5, 1960. They were identified with the aid of Berry (1959:424). Upon being landed on the beach they emitted a series, or burst, of rapid, short, rasping croaks. The sounds lasted for three or four seconds, followed by a two or three second interval of silence. They continued making the noise for about a minute while in hand until placed in a live jar. The noises were audible for a distance of about five feet. They were assumed to have been made by the grinding of the upper and lower teeth as is characteristically done by the family, and definitely not by the clicking of dorsal fins as has been reported by Fish (1954:30) for carangids.

The 41 mm specimen was dissected to check the development of the upper and lower pharyngeal teeth in relation to the air bladder (Fig. 1). Dorsally there were three paired patches of small

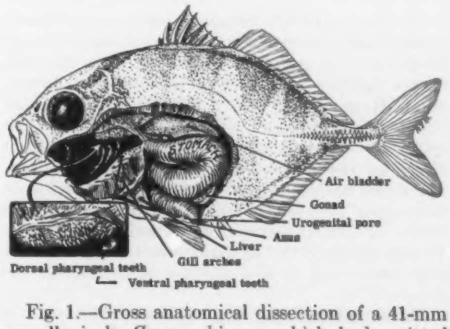

Fig. 1.—Gross anatomical dissection of a 41-mm crevalle jack, *Caranx hippos*, which had emitted rasping croaks, to show the development of primary sound-making structures of pharyngeal teeth in relation to other organs. Drawing by A. J. Mansueti.

[1] Contribution No. 152, Maryland Department of Research and Education, Solomons, Maryland.

villiform teeth which are larger than the premaxillary teeth. Ventrally there was a single pair of triangular patches of similar but smaller teeth. The delicate air bladder occupied the entire length of the body cavity and about one-quarter the depth. It is clear that the important anatomical features necessary for stridulatory sound-making were present. Thus, the sounds heard on the beach, which are interpreted to denote alarm, were similar in mechanical origin to those made by larger individuals which are believed to combine teeth rasping and air bladder resonance.

The full stomach of the 41 mm specimen was found to contain about 0.5 cc. of crustacean remains. They consisted largely of mysid shrimps and megalop stages of an unknown species of seaside crab, according to a tentative identification by Mr. David G. Cargo, carcinologist at the Chesapeake Biological Laboratory.

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The Barnacle, *Platylepas hexastylos*, Encrusting a Green Turtle, *Chelonia mydas mydas*, from Chincoteague Bay, Maryland[1]

ABSTRACT

First record of the green turtle, *Chelonia mydas mydas*, in Maryland's Chincoteague Bay is presented. Also, the second known observation of a barnacle, *Platylepas hexastylos*—green turtle association is discussed.

On May 6, 1959, a female green turtle, *Chelonia mydas mydas* Linnaeus, (31″ total carapace length, weighing 73 pounds) was captured when its right flipper became entangled in a crab pot line at White Rock (38° 03′ 30″ N, 75° 17′ W) in Chincoteague Bay, Worcester County, Maryland. This specimen was moved to a pen in the Patuxent River at the Chesapeake Biological Laboratory, Solomons, Maryland, and held until it was released September 14, 1959, bearing two strap monel tags (CBL 17 and 18) attached to the carapace. Tag 17 was attached to the right side near the widest point while Tag 18 was attached to the rear of the carapace.

On examination of this specimen, hundreds of the barnacle *Platylepas hexastylos* (O. Fabricius) were found attached to the carapace, plastron, dorsal portions of the head and neck, and the dorsum of all flippers. Specimens ranged from 3–15 mm in diameter.

This association of *Platylepas hexastylos* with *Chelonia mydas* has been observed in North America only one other time. Richards (1930:143–4) found *P. hexastylos* on the skull of a green turtle in Delaware Bay near Cape May, New Jersey (specimens USNM 115760). The capture of the green turtle in Chincoteague Bay is noteworthy as it constitutes not only the second record of this barnacle-turtle association in North America, but it is the first authentic record of this turtle in Chincoteague Bay.

In addition to the record given by Richards above, *P. hexastylos* (see Pilsbry, 1916:285–6, for synonyms) has also been recorded at Osprey, Florida (Pilsbry, 1916:286). Holthuis (1952:72–8) reports this species on a turtle [*Thalassochelys* (= *Caretta*) *caretta*] cast ashore at Ouddrop in 1894. Darwin (1854:428–9) described the species from manatees in the River Gambia and also noted it on turtles captured in the Mediterranean. Pilsbry (1916:285–6) states that this barnacle has been found on African and American manatees and dugongs, while the small (7–8 mm) delicate, oval or rounded subspecies, *P. h. ichthyophila*, is known

[1] Contribution No. 153. Maryland Department of Research and Education, Solomons, Maryland.

from the gar *Lepisosteus* in brackish waters of Hernando County, Florida. The present specimens compare rather well with his description of *P. hexastylos*. As Darwin (1854:fig. 1B) illustrates, growth ridges were quite evident on the circular specimens examined. Scallations and indentations were quite evident in each of the six plates comprising an individual.

Thanks are due Dr. John D. Costlow, Jr., Duke University Marine Laboratory, Beaufort, North Carolina, for identification of the barnacles and with whom they are deposited, and Dr. Fenner A. Chace, Jr. Curator, Division of Marine Invertebrates, U. S. National Museum, for access to the Darwin and Pilsbry papers on *P. hexastylos*.

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The Occurrence of the Rough Scad, *Trachurus lathami*, in Chesapeake Bay, Maryland[1]

ABSTRACT

The rough scad, *Trachurus lathami* Nichols, is recorded from the Maryland part of Chesapeake Bay for the first time. It was captured in a trawl towed at a depth of 60 feet on July 21, 1958 at a salinity of about 14 ppt. The specimen was 102 mm standard length, apparently from age group I based on scale examination, and somewhat smaller than average size.

The rough scad, *Trachurus lathami* Nichols, a carangid fish distributed from Massachusetts to the Gulf of Mexico region, has never been recorded in Maryland waters. A five-inch specimen was taken in a 30-foot semi-balloon shrimp trawl on July 21, 1958 during the joint trawl survey of Chesapeake Bay sponsored by Maryland's Chesapeake Biological Laboratory and the Virginia Fisheries Laboratory. It was trawled at about 60 feet in mid-Chesapeake Bay off the mouth of the Potomac River between Point Lookout, St. Marys County, and Smith Island, Somerset County, at Station CBM-10 of the joint survey. The present record apparently also constitutes a new record for estuarine penetration. Salinity and temperatures values recorded at this station were: surface—11.0 ppt and 27.0°C; and bottom—16.9 ppt and 25.4°C.

This record is noteworthy because the species has always been considered rare on the Atlantic coast (Nichols, 1920:479), although in recent years a number of important records have been published. Merriman (1943:205) presented some locality data while Ginsburg (1952:88) gave the most complete summary of its distribution. Massmann (1960A:70 and 1960B) recorded four specimens from Virginia in the lower Chesapeake Bay and off its mouth during June through August, 1954, 1957 and 1958 and several additional records during 1959.

The Maryland specimen possesses features typical of those cited by Ginsburg and Merriman: lengths, standard—102 mm, fork—111 mm, and total—127 mm; dorsal fin rays, VIII-I, 29; anal fin rays—II-I, 28; pectoral fin rays, 21; non-keeled scales in curved anterior part of lateral line, 33; keeled scales in posterior straight part, 37; length of pectoral fin, 28 mm; body depth at beginning of anal fin, 28 mm; body depth at pelvic base, 28 mm. Fig. 1 embodies all the counts above and typical features of the species as described by Ginsburg. It differs from the Rhode Island specimen figured by Goode (1884:atlas, pl. 103) and copied by Jordan and Evermann (1896–1900: pl. 140) and Jordan (1925:489, fig. 384) in that: (a) the anterior lateral line scales are not keeled as Merriman (1943:206) first emphasized, and (b) they are smaller in number (range 66–74 given by Ginsburg, 1952:88, rather than 77 given and illustrated by Jordan and Evermann, 1896:910). Thus, Goode's figure is somewhat atypical for the species. It is possible that the artist, H. L. Todd, may have referred to European specimens of *Trachurus trachurus*, with which *T. lathami* was early identified, while executing his drawing.

Judging from sizes cited by other authors, this specimen was somewhat smaller than average. Dissection did not reveal gonads mature enough for sex identification. The pectoral fin extended past

[1] Contribution No. 154, Maryland Department of Research and Education, Solomons, Maryland.

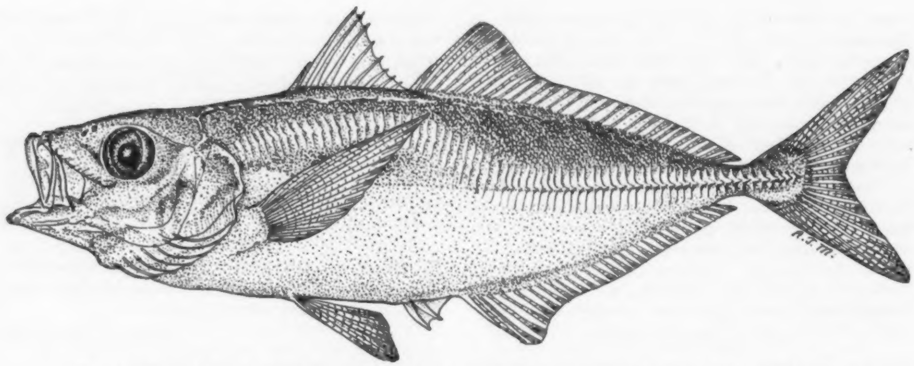

Fig. 1.—Rough scad, *Trachurus lathami*, taken off the Potomac River, in Chesapeake Bay, Maryland, showing the unkeeled nature of the anterior lateral line scales. Life size. Drawing by A. J. Mansueti.

the origin of the soft anal, which condition Ginsburg (1952:88) stated was typical of large specimens. It was almost identical in size to the Massachusetts individual cited by Merriman (1943: 206), who aged his specimen as a yearling with a single annulus on the scale. About 10 scales taken from behind the pectoral fin and beneath the curve of the lateral line on the Maryland specimen were studied. A faint ring similar to that shown for the 103 mm scad shown in Merriman's Plate IC was detected on most of the scales. If this mark is a true annulus, then Merriman's provisional generalization that juveniles range up to about 75–80 mm in length, while yearlings average 140–175 mm, after which size they may be two or more years old, may be correct. The scales from the Maryland specimen were shaped like those given by Merriman in Plate IC. The number of circuli from the focus to the anterior edge of the central radius were also similar: Maryland specimen, 34; and Massachusetts specimen, about 30.

Although Ginsburg regards this species as pelagic, he acknowledged that many of his Gulf of Mexico specimens were apparently taken by trawls at depths of 7–45 fathoms. Massmann (1960: 70) took all of his Virginian specimens in a trawl identical to that used during the Maryland-Virginia survey. Merriman took his specimen by hook and line. Thus, this species frequents near or on the bottom, but it is possible that some specimens are taken in mid- or surface water as the trawl is being hauled aboard the vessel. The species associated with the Maryland specimen in the catch do not help in the determination of its depth distribution. Thus, the following species were taken at the same time: benthic species—croaker, *Micropogon undulatus*; summer flounder, *Paralichthys dentatus*; and hogchoker, *Trinectes maculatus*; mid-water or pelagic species—menhaden, *Brevoortia tyrannus*, bay anchovy, *Anchoa mitchilli*, and weakfish, *Cynoscion regalis*.

The specimen is now part of the scientific collection of the Chesapeake Biological Laboratory. Grateful acknowledgment is expressed to William Massmann, Biologist-Captain of the vessel *Pathfinder* of the Virginia Fisheries Laboratory for information on this species, additional Virginia records and for field facilities.

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Predation of Eggs of the Spotted Salamander, *Ambystoma maculatum*, by the Leech, *Macrobdella decora*[1]

ABSTRACT

Predation of the eggs of the spotted salamander by leeches is illustrated by a photograph for the first time. *Macrobdella* was observed to penetrate and mechanically damage a gelatinous mass of salamander eggs in a small Coastal Plain pond in Maryland. Ingestion was ascertained by the discovery of egg mass particles in the stomach of a 4½ inch leech.

The predation of salamander eggs by leeches is such an unusual occurrence that the following observations may be of interest. A leech-like organism was first observed on April 3, 1960 near an egg mass of the spotted salamander, *Ambystoma maculatum* (Shaw), in a small, swampy Coastal Plain pond at Long Beach, Calvert County, Maryland. This pond, less than a yard in diameter, was also inhabited by breeding spring peepers, *Hyla crucifer* (Wied), and presumably by other hylid and ranid frogs. Active predation by several leeches was observed the following night, when many more salamander egg masses were observed. On one of the masses, three large and very active leeches, subsequently collected and identified as *Macrobdella decora* Say, were seen continuously penetrating into and through the mass of eggs. Their activities had mechanically damaged the gelatinous mass surrounding the eggs so that it had a loose and flabby texture. Moore (1923:24, 32) has given the most detailed and extensive account, among several references in general texts, of the consumption of eggs of frogs by this species of leech, but he did not mention predation on salamander eggs.

After the flash photograph (Fig. 1) was taken, the egg mass which contained the leeches was dipped up with a bucket and held for observation. The leeches began swimming rapidly around in the bucket and then crawled out onto the floor. They were then killed in warm water and preserved. The salamander eggs, obviously in an advanced stage of development, hatched the next day as the water warmed to room temperature. Two of the leeches were relatively large and robust, and were estimated to range from eight to 10 inches when extended. The other individual was smaller, perhaps five to six inches long. Both the eggs and the surrounding envelope of gelatin were damaged but the actual ingestion of material by the leeches was not observed. Examination of the stomach

[1] Contribution No. 155, Maryland Department of Research and Education, Solomons, Maryland.

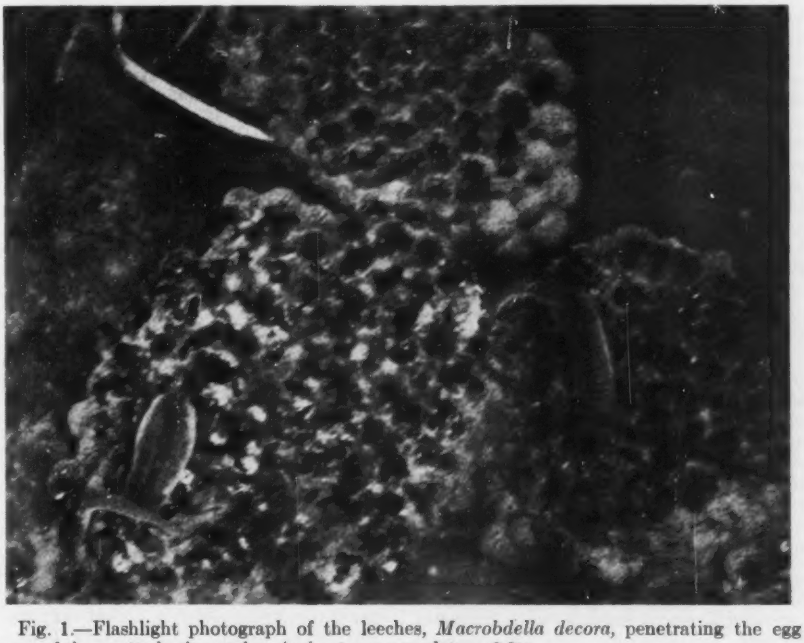

Fig. 1.—Flashlight photograph of the leeches, *Macrobdella decora*, penetrating the egg mass of the spotted salamander, *Ambystoma maculatum*. 0.6×.

material of one of the leeches 4½ inches long in a partially relaxed state, however, revealed several large fragments of egg cases and several lumps of translucent gelatinous material presumably from the *Ambystoma* egg mass. These observations illustrate and add spotted salamander eggs to the known predatory activities of this leech.

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Organ-Body Weight Relationship in the Toadfish, *Opsanus tau*[1]

ABSTRACT

The following organs from male and female specimens of *Opsanus tau* were weighed: heart, liver, spleen, gut, brain, eyes. Prediction equations for organ weight in terms of total body weight were derived. Best correlation was found between weight of eyes and body weight. A hyperbolic relationship between total body weight and brain as percent of body weight was postulated.

INTRODUCTION

The relationship of the weight of various organs to that of the total body has been worked out very well for mammals and for some birds (Brody, 1945). Such information for fish is meager. Krumholtz (1956) has reported on the problem in fish in recent times, while Hesse (1921) is one the older papers which covers part of this subject.

The toadfish, *Opsanus tau*, is common in the Chesapeake Bay. Although it is useful as an experimental animal because of its abundance and its hardiness, it has no current economic value. Moreover, aside from early studies on the life history and embryology of the species (see Bigelow and Schroeder, 1953, for references), essentially no detailed scientific information has been published on the toadfish.

We, therefore, decided to make a general biological study of the species with emphasis on the quantitative aspects. The present paper is the first of a proposed series. It deals with the relationships of the weight of various organs in the body of the toadfish to the weight of the body as a whole.

MATERIAL AND METHODS

Toadfish were obtained by trapping in the lower Patuxent River estuary, Maryland. They were removed from the water and weighed on a spring balance to the nearest gram. The spinal cord was then severed behind the skull and the following organs dissected out: brain, eyes, liver, heart, gut, spleen. Before weighing, the ventricle of the heart was cut open and any blood flushed out. Conus arteriosus and sinus venosus were included in heart weight. All organs were weighed on a microtorsion balance to the nearest milligram.

RESULTS

Table 1 summarizes the data on the population of toadfish that we used. It is evident that both very young and old adult specimens were included in our sample.

Individual prediction equations for organ weight in terms of body weight were calculated by the method of least squares using logarithms of the weights and absolute weights. Table 2 shows coefficients of correlation for these various equations. The equations are of the straight line type, $y = a + bx$, where y is the organ weight in grams and x is the body weight in grams. From Table 2 it is evident that if one uses the logarithms of all weights more precise prediction equations result; i.e., the form $\log y = a + b \log x$ expresses most closely the relationship of all organs in the toadfish to body weight (Table 3). For sake of comparison, the prediction equations using actual weights are given in Table 4. It is emphasized that in general the equations in Table 3 are more exact than those in Table 4.

DISCUSSION

A number of interesting relationships can be derived from the data. For example, if one plots the body weight against percent of body weight accounted for by the eyes a straight line results:

$$y = 0.89 - 0.001x$$

where x and y are body weight and percent eye weight, respectively. In other words, as the toadfish grows in size, the eyes make up less and less of the total body weight. We might refer to the eyes as hypomegalistic, i.e. they grow at a slower rate than the body as a whole; for each 100 gram increase in body weight the eyes make up 0.1 percent less of the total body weight.

The brain shows a somewhat different pattern, although it is also hypomegalistic. If one plots body weight against percent of body weight accounted for by brain in the toadfish on ordinary coordinate paper, there is a clear decrease in percent brain weight with increase body weight.

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However, the amount of decrease declines, as the body weight rises, until percent brain weight becomes asymptotic with the x axis at about 350 grams body weight. From 360 to 600 grams body weight the brain accounts for about 0.03 percent of the total weight.

Heart and gut are also hypomegalistic. Liver and spleen, on the other hand, are hypermegalistic, i.e., they grow at a greater rate in the toadfish than does the body as a whole. The variability in these two organs is quite large compared to the other organs.

Exner and Routil (1958) have reported data on the relationship of brain to body weight in a number of fish. In general these species show a pattern of brain-body weight relationship which is similar to the one that we are reporting for the toadfish. Large fish (the northern pike, *Esox lucius*, weighing 12,700 grams) have a small percentage of that weight (0.04 percent) accounted for by brain. Smaller fish (threespine stickleback, *Gasterosteus aculeatus*, weighing 1.45 gram) have a larger proportion of the body weight (1.5 percent) accounted for by brain.

We suggest the hypothesis that in general (interspecifically and intraspecifically) small specimens of fish have a significant part of the body weight (approaching 2 percent) accounted for by brain weight. With increase in body weight the percent of that weight accounted for by the brain declines in a decreasing fashion until a minimum of about 0.03 percent body weight is reached at which point the curve becomes asymptotic.

TABLE 1.—Summary of data on body weights of toadfish, *Opsanus tau*.

Statistic	Males	Females
Number	77	55
Mean wt., gm	217	162
Mode	150	150
Median	192	150
Range	30–530	34–357
Standard Deviation	±104	±72
Skewness	±0.75	±0.54
Grand mean, gm	194	

TABLE 2.—Coefficients of correlation for equations expressing body weight versus weight of each organ in the toadfish, *Opsanus tau*.

Item	Coefficient of correlation					
	Heart	Liver	Spleen	Gut	Brain	Eyes
Actual weights, Male	0.947	0.536	0.846	0.253	0.829	0.911
Actual weights, Female	0.952	0.876	0.767	0.967	0.926	0.940
Log of weights, Male	0.969	0.907	0.863	0.968	0.834	0.979
Log of weights, Female	0.975	0.908	0.755	0.984	0.902	0.946

TABLE 3.—Values for a and b in the prediction equation $y = a + bx$ in which y and x are logarithms of weights of organs and body, respectively, in the toadfish, *Opsanus tau*.

Organ	Males		Females	
	a	b	a	b
Heart	−3.6	1.2	−3.9	1.3
Liver	−2.5	1.2	−1.86	1.03
Spleen	−5.3	1.51	−6.36	1.78
Gut	−1.66	1.02	−2.07	1.13
Brain	−1.62	0.61	−1.42	0.59
Eyes	−1.3	0.8	−1.4	0.8

TABLE 4.—Values for a and b in the prediction equation $y = a + bx$ in which y and x are actual weights of organs and body, respectively, in the toadfish, *Opsanus tau*.

Organ	Males		Females	
	a	b	a	b
Heart	−0.073	0.002	−0.127	0.0026
Liver	−10.56	0.052	−0.137	0.018
Spleen	−0.038	0.001	−0.031	0.001
Gut	−56.1	0.305	−1.03	0.039
Brain	0.037	0.0003	0.031	0.00047
Eyes	0.227	0.005	−0.02	0.008

The form of the curve relating brain as percent of body weight to total body weight in fish is an hyperbola.

In a marine mammal, the harbor seal, *Phoca vitulina*, the heart weight as percent of body weight decreases in size somewhat as follows: $y = 0.99 - 0.007x$, where y is percent heart weight and x is body weight in kg. In the common harbor porpoise, *Phocaena phocaena*, the percent heart weight varies with body weight as follows: $y = 7 + 0.038x$ where x and y are body weight in kg and percent of body weight accounted for by heart, respectively (Slijper, 1958).

The primary purpose of this paper is descriptive; we hope to make a record of the growth of selected organs with respect to total body growth in a single fish species, *Opsanus tau*. Elaborate discussion of the data at this time is not warranted. We plan to follow this paper with similar ones on other species of fish and to conclude with a theoretical paper in which we can generalize from the accumulated data.

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The Correlation of Length, Weight and Girth in the Toadfish, *Opsanus Tau*[1]

ABSTRACT

Length, girth and weight were taken from a series of toadfish. Prediction equations for each variable in terms of another were derived. It was found that these various measurements correlate so highly with one another (r = 0.97) that they can be used interchangeably in making comparisons of various kinds.

As part of an overall program of study on the toadfish, *Opsanus tau*, we became interested in the the relationships of body weight, length, and girth to one another. Visual inspection of toadfish of various sizes gives the impression that individuals of this species do not increase proportionately in weight and length. In order to ascertain how this species grows in terms of mass and of linear measurements we weighed and measured a population of toadfish of various sizes.

MATERIAL AND METHODS

Toadfish were trapped from the Patuxent River estuary in the vicinity of Solomons, Maryland. Fresh total body weight was recorded to the nearest gram. Total length (from tip of upper jaw to end of compressed tail) to the nearest mm, was measured with a meter stick fitted with a stationary and a movable stop. Girth was measured to the nearest mm using the wet string method. The string was passed around the body of the fish at the posterior margin of the operculum; the plane surface delimited by the string was kept at right angles to the long axis of the body.

The data were plotted on coordinate paper and prediction equations were derived for the different variables.

RESULTS

Table 1 shows a summary of the data. Preliminary evaluation of the results showed no advantage to be gained by separating the sexes. Therefore, in view of the small number of females, correlations were done on the total number of fish used (70) regardless of sex.

When the results for weight versus girth and length versus girth were plotted on normal coordinate paper, the points grouped themselves very closely in 2 straight lines. It was therefore decided to fit the data to a straight line, $y = a + bx$. (Table 2). It is clear that length, girth, and weight in the toadfish vary linearly among one another in a highly predictable fashion. The change in length with increase in weight is relatively small ($b = 0.13$)—a fact which is in accord with the visual impression one gets of the length-weight relationship in this species.

DISCUSSION

In studies on trout a condition factor K has been used to relate weight and length; $K =$ weight 10^4/ length^3. K is reported to be about 100 if the metric system is used (Ball and Jones, 1960). Using our

TABLE 1.—Summary of data from the toadfish, *Opsanus tau*, on which the correlations were made.

Item	Value	Range	Stand. Dev.	Stand. Err.
Mean length, mm	243.3	166–323	32.7	3.8
Mean girth, mm	185.2	123–250	26.4	3.1
Mean weight, gm	288.1	85–501	86.6	10.0
Number of males	57	—	—	—
Number of females	13	—	—	—

TABLE 2.—Constants for prediction equation, $y = a + bx$, where x is either weight or length and y is girth or length in the toadfish, *Opsanus tau*.

Correlation	a	b	r	r^2
Length × girth	47	0.56	0.97	0.94
Weight × girth	116	0.24	0.97	0.94
Weight × length	207	0.13	0.98	0.96

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mean values we calculated $K = W \cdot 10^4/L^3 = 200$ and $K = W \cdot 10^4/\text{Girth}^3 = 455$. This condition factor (body factor, Korpulenzfaktor) for the bream has been calculated as about 233 for spring specimens and 259 for winter specimens. Suworow (1959) maintains that for the female bream the value of K varies from 180 in dystrophic areas of the water to 270 in eutrophic areas. Our K value for the toadfish falls within this range.

In the small tarpon, Harrington (1958) found that

$$\text{weight} = -150 + 55.14 \times (1.069)^{\text{Length}}$$

In other words weight in this species increases at a much greater rate than is explained by the "cube law", $w = cL^n$.

The equation $w = a\ l^b$ is not particularly satisfactory for expressing the weight-length relationship in the toadfish, although it gives useful information for a number of other species (Ricker, 1958). The coefficient b varies from one species to the next and in the same species under various environmental and nutritional conditions.

Our data show (Table 2) that for each gram of weight increase in the toadfish the length increases 0.13 mm and the girth 0.24 mm. Similarly for each mm increase in length, the toadfish increases 7.7 gm in weight; for each added mm in girth, the weight increases 4.2 gm.

In view of these results, it is suggested that length or girth of the toadfish can be used, as satisfactorily as total body weight, for a basis of comparison.

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An Unusual Winter Survival of a Young Spadefish *Chaetodipterus faber*[1]

ABSTRACT

A young-of-the-year (60.8 mm standard length, 77.7 mm total length) spadefish, *Chaetodipterus faber*, was found to survive low winter temperatures in shallow tidewater a few feet from the Chesapeake Bay, Calvert County, Maryland. It was discovered in a temporary shore pool at a water temperature of 7.5°C (44.5°F) with a salinity of 16 ppt. in December, 1959.

Young or adult spadefish, *Chaetodipterus faber* (Broussonet), are not known, throughout their range, to inhabit shallow waters of less than 36 feet during the winter months (Gunter, 1945:179–80: Joseph and Yerger, 1956:139: Hildebrand and Schroeder, 1928:307–8: Springer and Bullis, 1956: 89: Springer and Woodburn, 1960:68–9). Although Hildebrand an' Schroeder caught specimens of this species 85 mm (3½ inches) long off the mouths of the Potomac and Rappahanock Rivers in October, they were taken in water depths ranging between 45–132 feet. Springer and Woodburn (1960:68) cited the discovery of a 162 mm specimen in a boat basin near their Maximo Point station during December after a cold wave had struck the area. No mention, however, is made whether the specimen had washed in or was found recently dead.

A young *C. faber*, 60.8 mm standard length (77.7 mm total length), was found on December 6, 1959 in a small temporary shore pool 200 feet south of the Cove Point lighthouse, Calvert County, Maryland. It aparently had been washed into this pool, which was 3 feet long and 0.5 feet deep, during a recent northeaster. It was sluggish in its movements yet appeared to be normal and tolerant of the conditions in the pool. The water temperature of the pool was 7.5°C (44.5°F) while the salinity was 16 ppt. The adjacent Chesapeake Bay water temperature and salinity was 7.7°C (45.8°F) and 16 ppt, respectively. The air temperature in the area reached a maximum of 46 during the day while nightly low was 34°F. Similar air temperatures had been recorded the days previous to this observation. Gunter (1945:79) noted that *C. faber* prefers salinities between 11.1–35.8 ppt and temperatures of 17.1–29.0°C, while Springer and Woodburn (1960:69) found this species tolerating salinities of 20.7–33.4 ppt and water temperatures of 19.5–32.5°C in Tampa Bay, Florida. The October specimens recorded in the lower Chesapeake Bay by Hildebrand and Schroeder (1928:308) may have been taken within salinity and temperature ranges

[1] Contribution No. 159, Maryland Department of Research and Education, Solomons, Maryland.

of 19-23 ppt and 16–18°C, respectively (Whaley and Hopkins, 1952: Salinity and Temperature Charts for 40–60′; Cruise VII, October 14 to Nov. 2, 1950).

The present specimen was a young-of-the-year, since an examination of its 1.4 mm long scale did not reveal an annulus. Undoubtedly it was a product of the previous late June or early July spawning in Chesapeake Bay (Ryder, 1887:521; Hildebrand and Schroeder, 1928:307). Specimens three inches long are considered by Smith (1907: 335) and Hildebrand and Cable (1938:536) to be of a June spawning. The body depth of 49.0 mm was higher in profile and was not as bulged forward as shown for a 50 mm specimen by Hildebrand and Cable (1938:542). The dorsal and anal fins were shorter than depicted by Hildebrand and Schroeder (1928:307). The largest dorsal spine was 15.5 mm long while the longest anal spine was 8.6 mm. The relatively large eye was 6 mm in diameter. The pelvic fins were large (26 mm) and extended beyond the second anal spine. Coloration was similar to that of adults.

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Comments on the Smooth Dogfish, *Mustelus canis*, from Chesapeake Bay, Maryland[1]

ABSTRACT

Five recent distributional records of the smooth dogfish, *Mustelus canis*, are presented from widely separated localities in Chesapeake Bay, Maryland.

Truitt, Bean and Fowler (1929:29), without elaboration, recorded the smooth dogfish, *Mustelus canis* (Mitchill), from Chesapeake Bay and Worcester County. Records from the latter location were probably from the seaside rather than Chesapeake Bay. Gunter (1942:316) cited this shark at the head of the bay in the tidal fresh waters of the Northeast River, Cecil County. Perhaps *M. canis* had entered that area from Delaware Bay via the Chesapeake and Delaware Canal. The survey by Hildebrand and Schroeder (1928:47–8) did not record *M. canis* from Chesapeake Bay; however, it was included in their species list on the basis of observations by Radcliffe at Gwynns Island and Buckroe Beach, Virginia. It is the purpose of this note to bring up to date records of this species from the upper Chesapeake Bay in Maryland.

Five specimens of *M. canis* have been taken from widely scattered localities in the upper bay since those were noted above. A 762 mm male *canis* was caught on hook and line using peeler crab as bait June 21, 1959 on the Northeast Middle Grounds (38° 02′ N 76° 11′ W) near the mouth of the Potomac River. A pound net in bay water 18 feet deep at Flag Pond (Calvert County) yielded a 764 mm female July 5, 1959. Hook and line fishing with peeler crab as bait on Great Rock oyster bar (37° 56′ N 76° 56′ W) in Tangier Sound (Somerset County) on July 23, 1959 produced a 780 mm female. A pound net set in 15 feet of water near Curtis Point in the West River, Anne Arundel County, accounted for a 741 mm male specimen July 27, 1959. Haul seining in the Choptank River at Todd's Point, Dorchester County, produced a 840 mm male *M. canis*. Several additional specimens were taken in the Choptank River and Tangier Sound near Crisfield, Maryland during the summer of 1960; however, these were not examined or verified. Measurements of speci-

[1] Contribution No. 160, Maryland Department of Research and Education, Solomons, Maryland.

mens cited above were not possible since they were either sold immediately on the commercial market as "steakfish" or were kept frozen for county fair displays and later decayed and had to be discarded.

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COWLES, R. P. 1930. A biological study of the offshore waters of Chesapeake Bay. *Bull. U. S. Bur. Fish. 46(1091): 277–381.*

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